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DERIVATION OF NARROWBAND FREQUENCY-AGILE RADAR SIGNATURES FROM --ETC(U)

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DERIVATION OF NARROWBAND FREQUENCY-AGILE RADAR SIGNATURES FROM WIDEBAND DATA (ANALYSIS OF X-BAND DATA)

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This investigation demonstrated theoretically and experimentally that frequency-agile narrowband radar signatures can be derived from wideband data. The experimental work used X-Band satellite data from Lincoln Laboratory's Long Range Imaging Radar (Haystack). The computer programs required for deriving narrowband signatures from two dimensional radar images were delivered to AFAL with this report.

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INTRODUCTION

A study recently carried out by Calspan evaluated the characteristics of a number of radar systems with the possibility that such a system might be used to observe satellites. Two important characteristics of the candidate systems studied for this application were that they were narrowband and frequency-agile. However, no data were available on satellites that could be used in simulations of these systems. Calspan proposed that the required narrowband data could be obtained by filtering wideband data collected by the Long Range Imaging Radar (LRIR) (also known as the Haystack radar) operated by Lincoln Laboratory. In this report, narrowband means bandwidth such that individual scatterers on the satellite cannot be resolved.

It was determined that the work that needed to be done could be separated into two parts: Phase 1 would be the development of processing software and a proof of the concept using the single frequency data available for comparison, and Phase II would be a rather detailed analysis of frequency agile signatures corresponding to specific candidate radar systems. This report covers the Phase I work only, and due to a change in requirements for this data, Phase II will probably not be performed. Section 2 of this report is a mathematical justification of the method, with some details given in Appendix A. Section 3 briefly describes the method used to derive the required signatures from the data available and discusses the computer software, with details supplied in Appendix B. Finally, the results and conclusions are given in Section 4, and may be summarized: the method is sound, both in theory and practice.

SECTION II

MATHEMATICAL JUSTIFICATION OF APPROACH

In the frequency domain a wideband radar pulse may be thought of as several adjacent narrowband pulses. Thus it is quite reasonable to expect that individual narrowband pulses could be obtained from wideband pulses by some form of data processing. The purpose of this section is to show how this can be done and to define the restrictions and limitations of the process, both in general and for the specific case of the LRIR.

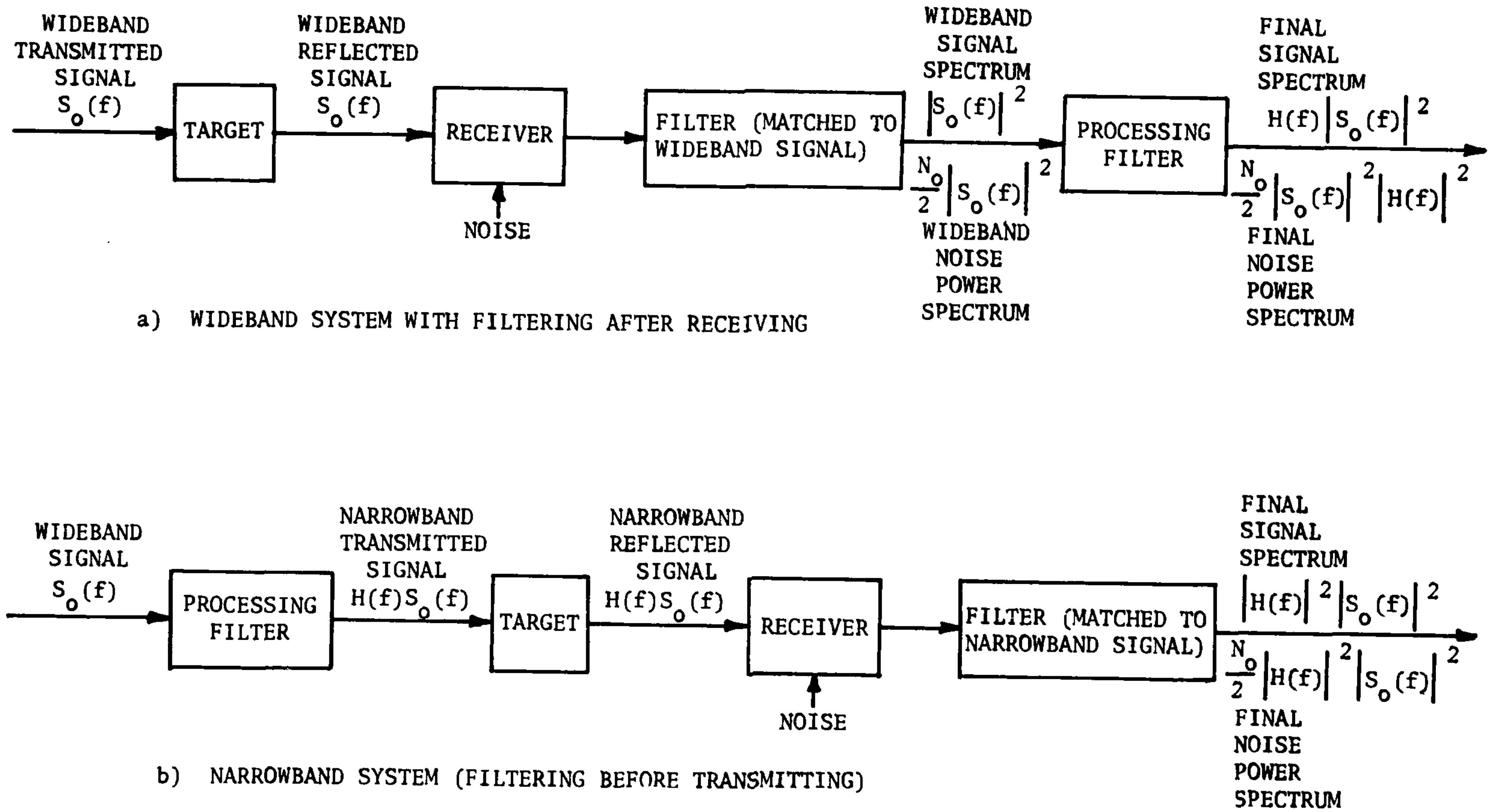
2.1 General Approach

Narrowband radar returns can be derived from wideband returns by a simple filtering operation. This can be shown quite easily by investigation of the received signal frequency spectrum. This analysis is carried out in detail in Appendix A and is summarized here.

Consider a transmitted waveform with transmitted energy E_T and spectrum $\sqrt{E_T}\, S_0(f)$ reflected from a point target as in Figure 2.1.a. The received signal has a spectrum $\beta\sqrt{E_T}\, S_0(f)$ where β is an attenuation factor. (For simplicity, Doppler shift has been omitted from this discussion although it could be included with no loss of generality.) This signal together with additive white Gaussian noise with power spectral density $\frac{1}{2} N_0$ is mixed down to the radar's intermediate frequency and input to a filter matched to the Doppler shifted signal. The filter signal output spectrum is $\beta\sqrt{E_T}\, |S_0(f)|^2$ with an additive noise component having power spectrum $\frac{1}{2} N_0\, |S_0(f)|^2$. Note that here the signal (which is deterministic) is represented by its spectrum while the noise (which is a stochastic process) is represented by its power spectrum. The output signal-to-noise ratio (SNR) is given by:

$$\mathrm{SNR} = \frac{(\text{Peak Signal})^2}{\text{Noise Variance}} = \frac{2\beta^2 E_T}{N_0}$$

Now a second filter H(f) is placed after the matched filter. The output from the second filter has a signal component spectrum $\beta\sqrt{E_T}\, |S_0(f)|^2\, H(f)$ and noise power spectrum $\frac{1}{2} N_0\, |S_0(f)|^2\, |H(f)|^2$. The output signal components for



a) WIDEBAND SYSTEM WITH FILTERING AFTER RECEIVING

b) NARROWBAND SYSTEM (FILTERING BEFORE TRANSMITTING)

Figure 1. COMPARISON OF WIDEBAND AND NARROWBAND RADAR SYSTEMS

this system (Figure 1-a) are $\beta\sqrt{E_T}\hat{S}_0$ where

$$\hat{S}_0(f) = S_0(f) \text{ for } |f-f_0| \leq B/2 \text{ and } |f+f_0| \leq B/2$$
$$= 0 \text{ otherwise}$$

Next, consider the system shown in Figure 1-b. The wideband signal with spectrum $S_0(f)$ is first passed through the filter H(f) and the narrowband signal $\sqrt{E_T}H(f)S_0(f)$ is transmitted. The received signal is $\beta\sqrt{E_T}H(f)S_0(f)$ which is input to a filter matched to the transmitted signal. The output has a signal component with a spectrum $E_T|H(f)|^2\ |S_0(f)|^2$ and a noise component with power spectrum $\frac{1}{2}\ N_0\ |H(f)|^2\ |S_0(f)|^2$.

The noise power spectra for the two systems shown in Figure 1 are identical, but their signal component spectra are slightly different. The signal components will only agree if $H(f) = |H(f)|^2$ for all f. Hence if H(f) is defined as:

$$H(f) = 1 \text{ for } |f-f_0| \leq B/2 \text{ and } |f+f_0| \leq B/2$$
$$= 0 \text{ otherwise}$$

Then the output of the wideband system with filtering after receiving is identical to the output of the system in which a narrowband signal was transmitted and received.

Notice that the output signal-to-noise ratio for either system is given by:

$$SNR = \frac{2\beta^2 E_T}{N_0} \left[\frac{\int_{-\infty}^{\infty}|\hat{S}_0(f)|^2 df}{\int_{-\infty}^{\infty}|S_0(f)|^2 df} \right]$$

where the term in brackets is the ratio of the narrowband transmitted energy to the wideband transmitted energy.

The conclusions are that:

1. Simulated narrowband data can be extracted from wideband field data by a filtering operation.

2. A narrowband transmitted waveform can be simulated whose frequency components within the simulated bandwidth are identical to those of the wideband signal within the same frequency limits and zero outside these limits.

3. There is a loss of signal-to-noise ratio in filtering wideband data to obtain narrowband data because the equivalent transmitted energy is less than the actual wideband transmitted energy.

2.2 Special Considerations for Haystack Radar

In the general discussion given above it is assumed that the wideband radar return passes through a filter exactly matched to a wideband pulse. The Haystack radar transmits a chirped pulse and mixes the received pulse with a replica of the transmitted pulse delayed in time to correspond to a return from a reference range and offset in frequency by the intermediate frequency. A return from the reference range will then give a signal at the center of the radar's intermediate frequency band. Returns from slightly different ranges will result in constant frequency signals with frequency proportional to range. However, these signals are also slightly displaced in time from the reference signal. The receiver filter is perfectly matched to the return from a scatterer at the reference range at a particular time, but at that time it is not perfectly matched to returns from scatterers at slightly different ranges. The purpose of this section is to demonstrate that this problem is negligibly small for satellites with dimensions of interest in this study.

Consider the way in which the chirp pulses are collapsed by Haystack.

Body Center at Range R_0

Scatterer i at range R_i is stationary and has RCS σ_i

Center Frequency $= f_0$

Swept Bandwidth $= B$

Pulse Duration $= T$

We use complex representation to simplify equations. The transmitted signal is represented as:

$$s(t) = e^{j2\pi[f_0 t + \frac{B}{2T} t^2]} \quad \text{for} \quad -T/2 \leq t \leq T/2 \tag{1}$$

The return from the i^{th} scatterer is:

$$r_i(t) = \sqrt{\sigma_i}\; e^{j2\pi[f_0(t-\tau_i) + \frac{B}{2T}(t-\tau_i)^2]} \tag{2}$$

for $\tau_i - T/2 \leq t \leq \tau_i + T/2$

where $\tau_i = 2R_i/c$.

This signal is beat against a replica of s(t) delayed by $\tau_0 = 2R_0/c$ and centered at a lower frequency $(f_0 - f_{IF})$.

$$y_i(t) = r_i(t)\; e^{-j2\pi[(f_0-f_{IF})(t-\tau_0) + \frac{B}{2T}(t-\tau_0)^2]} \tag{3}$$

$$= \sqrt{\sigma_i}\; e^{-j2\pi f_{IF}\tau_0}\; e^{j2\pi[f_0(\tau_0-\tau_i) + \frac{B}{2T}(\tau_i^2-\tau_0^2)]}\; e^{j2\pi[f_{IF} - \frac{B}{T}(\tau_i-\tau_0)]t}$$

for $-T/2 + \tau_i \leq t \leq T/2 + \tau_i$

Hence a scatterer at range i yields a CW pulse centered at τ_i at frequency $f_{IF} - \frac{B}{T}(\tau_i - \tau_0)$. Note that the duration of the chirp affects only the limits of the return; the phase and frequency of the return are fully determined by the chirp rate $(\frac{B}{T})$.

The return from several scatterers comprising a realistic target can be found by summing the $y_i(t)$ for each of the scatterers.

Figure 2 depicts the individual components, $y_i(t)$, (and their summation, $y(t)$) of the return from a scatterer located at τ_0, the reference range, one located slightly closer to the radar at τ_- and one located slightly farther from the radar at τ_+. The figure shows clearly the effect of the slight displacement of the individual scatterers from each other. Let us define a segment of $y(t)$ centered at t_0 with duration δ:

$$y'(t) = y(t) \qquad \text{for } \tau_0 - \frac{T}{2} \leq t_0 + \tau_0 - \frac{\delta}{2} \leq t \leq t_0 + \tau_0 + \frac{\delta}{2} \leq \tau_0 + \frac{T}{2} \tag{4}$$

$$= 0 \quad \text{otherwise}$$

The contribution of the i^{th} scatterer (i=+, 0, or -) in this signal is:

$$y_i'(t) = \sqrt{\sigma_i}\, e^{-j2\pi f_{IF}\tau_0}\, e^{j2\pi[f_0(\tau_0-\tau_i) + \frac{B}{2T}(\tau_i^2-\tau_0^2)]}\, e^{j2\pi[f_{IF}-\frac{B}{T}(\tau_i-\tau_0)]t} \tag{5}$$

where $t_0 + \tau_0 - \frac{\delta}{2} \leq t \leq t_0 + \tau_0 + \frac{\delta}{2}$

$$y'(t+t_0) = \sqrt{\sigma_i}\, e^{-j2\pi f_{IF}\tau_0}\, e^{j2\pi[f_0(\tau_0-\tau_i) + \frac{B}{2T}(\tau_i^2-\tau_0^2)]}\, e^{j2\pi[f_{IF}-\frac{B}{T}(\tau_i-\tau_0)][t+t_0]} \tag{6}$$

$$= \sqrt{\sigma_i}\, e^{-j2\pi f_{IF}(\tau_0-t_0)}\, e^{j2\pi[(f_0+\frac{B}{T}t_0)(\tau_0-\tau_i) + \frac{B}{2T}(\tau_i^2-\tau_0^2)]}\, e^{j2\pi[f_{IF}-\frac{B}{T}(\tau_i-\tau_0)]t} \tag{7}$$

where $\tau_0 - \frac{\delta}{2} \leq t \leq \tau_0 + \frac{\delta}{2}$

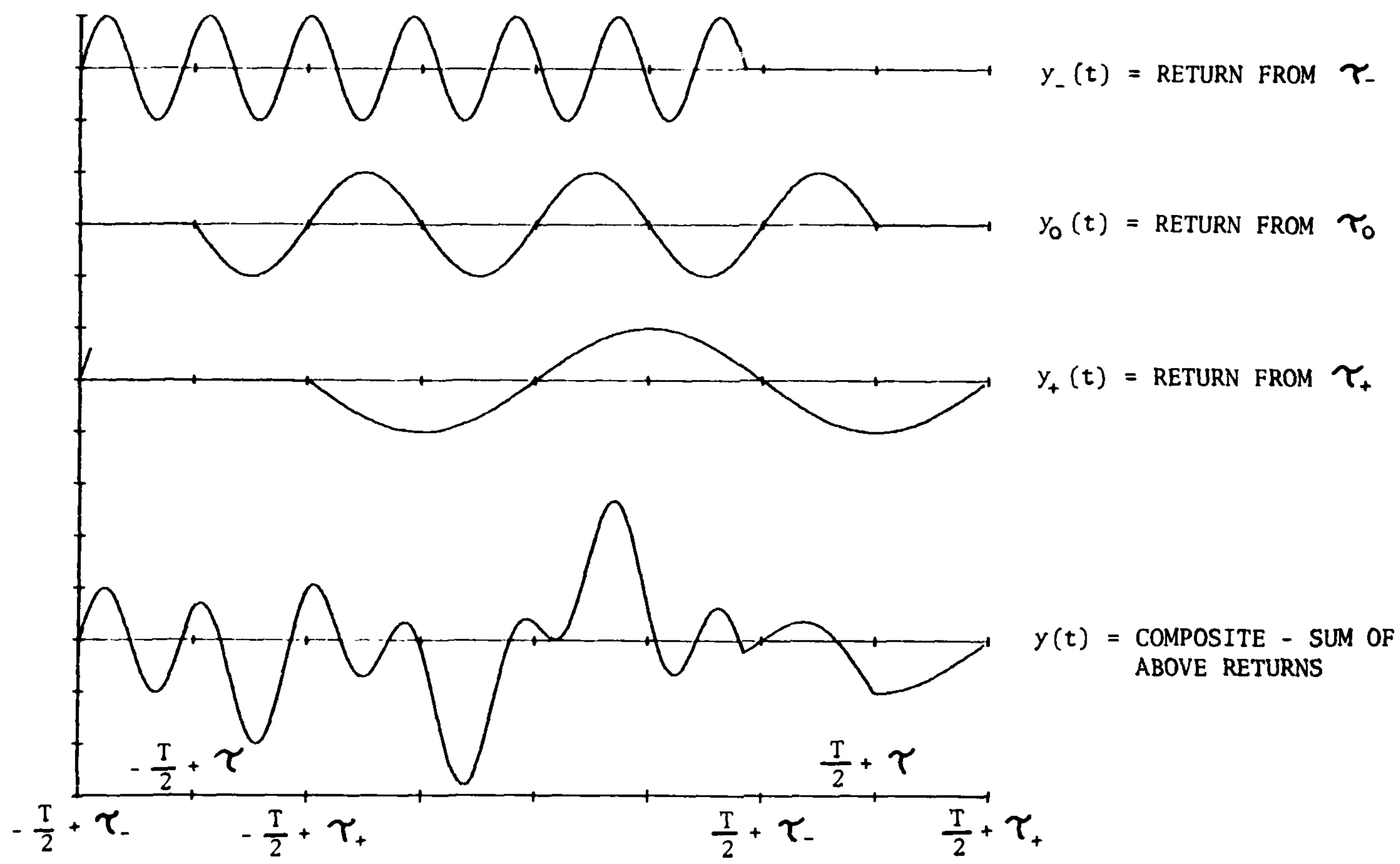


Figure 2 COMPONENTS AND COMPOSITE OF CHIRPED RETURN FROM 3-SCATTERER TARGET

Equation 7 has the same form as the completely general Equation 3. This shows that except for fringe or end effects, the signal from a multiple scatterer target is in all other respects completely general. Therefore, when the chirped radar pulse is very long in comparison to the range extent of the target ($\Delta\tau << \delta$), as it is for the LRIR looking at satellites of reasonable size, the filtering used with wideband radar returns is negligibly different from a true matched filter and, therefore, should not have a significant effect on the derivation of narrowband signals from the wideband data.

SECTION III
DESCRIPTION OF METHOD

As the discussion in the previous section implies, filtering wideband radar returns to obtain narrowband returns is a relatively simple process. Most of the effort in this study was related to the form in which the data were available. In order to minimize the effort required to obtain the data, understand and compensate for radar dependent characteristics, remove translational motion of the satellite, and be certain of the validity of the data, the most practical form for transferring the wideband data from Lincoln Laboratory to Calspan was in the form of two dimensional images. Since these images are the result of reversible processing of the needed wideband data, much of the software developed in this study was aimed at reversing many of the processing steps involved in creating the images.

One way to describe the methods used for this processing is briefly to review this imaging process. Figure 3 shows the ramp waveform transmitted by by LRIR. The received waveform is mixed with a delayed (to an appropriate reference range) replica of the transmitted waveform to generate the uncollapsed pulse. This pulse is digitized, Doppler corrected, weighted and Fourier transformed to obtain a high resolution pulse, where successive samples from the *transform* represent range samples near the reference range. Samples of many pulses at the same range relative to a reference point fixed on the target are weighted and Fourier transformed in the cross-range dimension to obtain Doppler or cross-range resolution of target scatterers. This final step is repeated for each sampled range, and the composite represents a two-dimensional image in the range-cross-range plane.

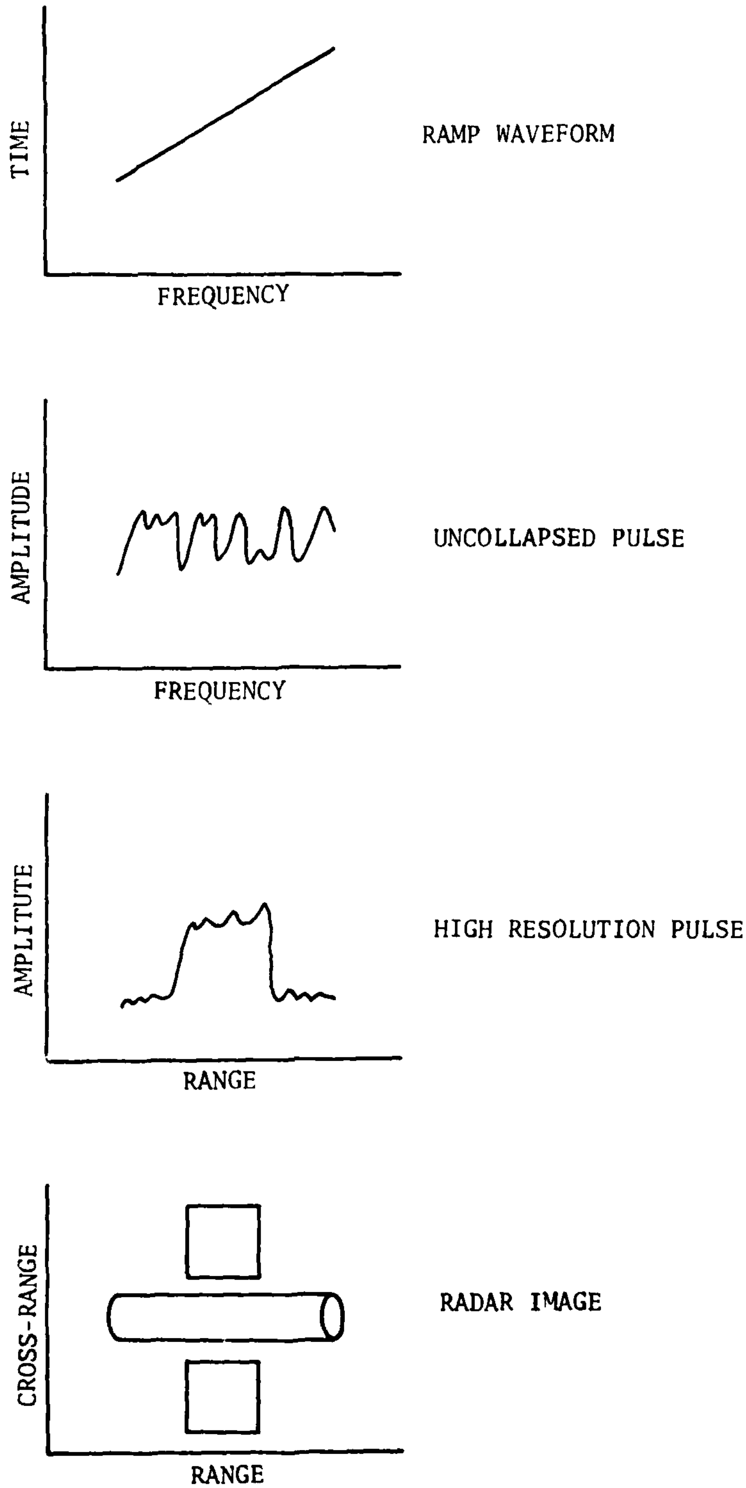


Figure 3   REVIEW OF IMAGING PROCESS

The software implemented in this study reversed most of the steps in image processing. It is important to note that two rather involved steps did not have to be reversed as they would have been required even if the raw data had been directly available to Calspan. The first of these was the compensation discussed in Appendix A to remove the apparent range shift due to Doppler frequency. The second was the very accurate range tracking of the target that was required to ensure that the same frequency could be selected from successive radar pulses.

The software implemented is summarized by the block diagram in Figure 4. The plotting of the two-dimensional images was done to ensure that the data were being read properly from the magnetic tapes. The narrowband images were plotted to facilitate eyeball correlations among signatures. The majority of the software performed the reverse image processing steps described above and presented various outputs to permit checking of intermediate results. Simple statistics were calculated to permit comparisons among actual narrowband signatures and derived narrowband signatures. This software is described in detail in Appendix B.

SECTION IV
RESULTS AND CONCLUSIONS

The primary purpose of this investigation was to demonstrate that narrowband signatures derived from wideband data are a good representation of actual narrowband signatures in practice as well as in theory. This section describes the results of performing the required comparisons.

The nature of the LRIR precluded, at reasonable cost, obtaining wideband and actual narrowband data simultaneously. The data available for this investigation are summarized in Table 1. Since the geometry differences from pass to pass would make the signatures quite different, only a qualitative pattern lobe correlation could be made between different passes; quantitative comparisons could be made on a statistical basis. Therefore, it was decided to concentrate on satellite 10352 since there were three actual narrowband signatures available to compare to each other and to the signature at the same frequency that could be derived from wideband data.

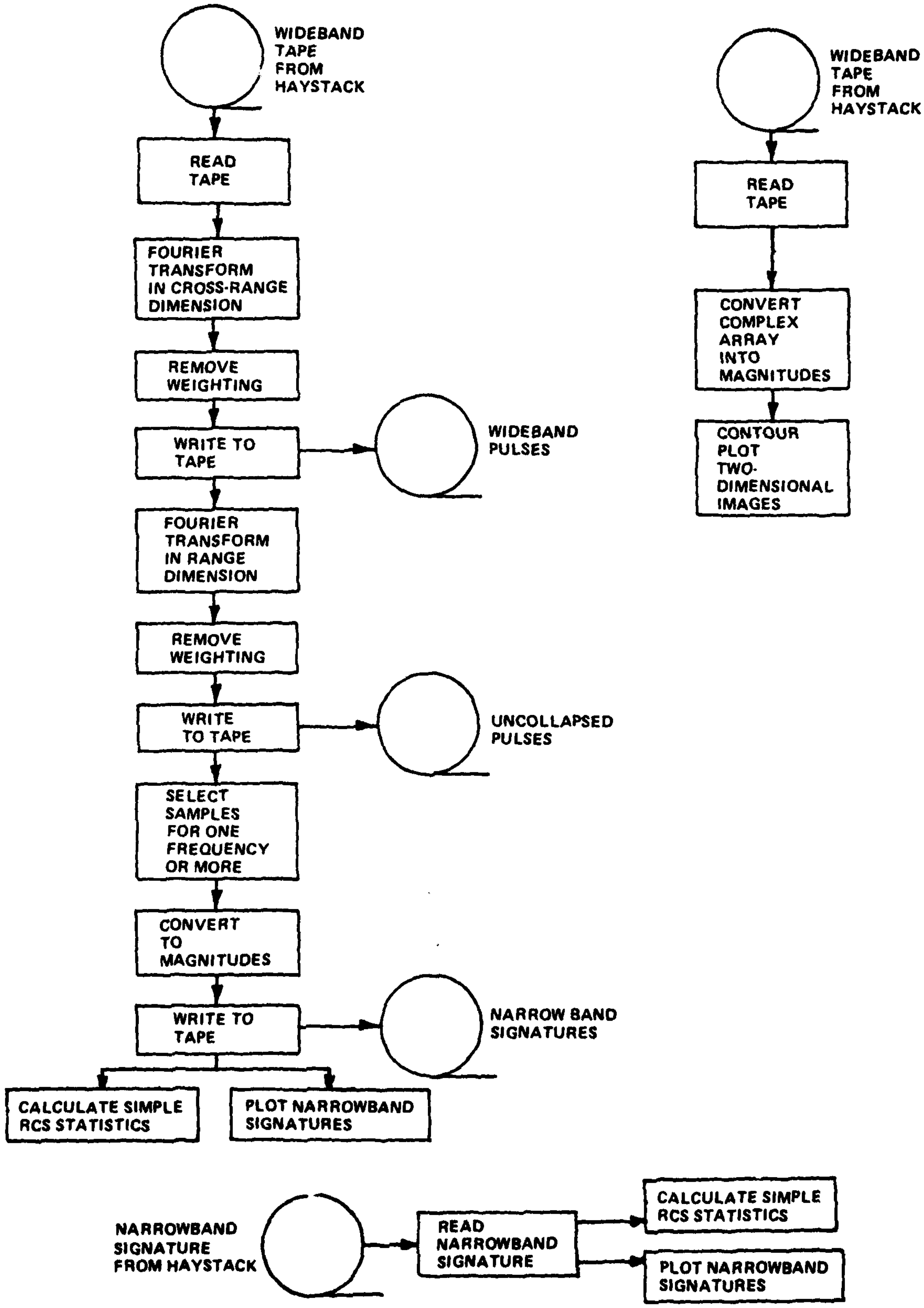


Figure 4 DATA REDUCTION SOFTWARE FUNCTIONAL DIAGRAM

TABLE 1

DATA RECEIVED FROM LINCOLN LABORATORY

NARROWBAND DATA			WIDEBAND DATA		
OBJECT	DATE	DURATION (SEC)	OBJECT	DATE	IMAGES
10129	11/9/78	460	10129	11/8/78	20
10973	9/20/78	465	10973	9/20/78	5
10141	11/9/78	700	10141	11/9/78	18
10352	11/8/78	520	10352	11/7/78	18
10352	11/8/78	730			
10352	11/9/78	560			
10917	9/19/78	770	10917	9/20/78	12
7490	11/9/78	605	7490	11/8/78	13
			10514	11/9/78	19
			11098	11/9/78	19
					TOTAL 124 IMAGES

The data from the three narrowband passes had been collected at either 100 or 200 pulses per second and a frequency of 10.0 GHz. Since this was much higher than the effective pulse rate (three to four pulses per second) used in the imaging process, groups of narrowband data were averaged to obtain a comparably low sample rate. This averaging also eliminated a non-random noise that, Lincoln Laboratory personnel agreed, was a figment of the radar operating in the narrowband mode rather than a characteristic of the satellite. These data were then plotted and statistics calculated to permit comparison to each other and to the signatures derived from the wideband data.

The wideband data from the pass of Object 10352 were processed as described in Section 3, selecting the same 10.0 GHz center frequency as used above. The signature segments derived from each image were concatenated to obtain a signature comparable to that from a narrowband pass. This signature was plotted and its statistics calculated.

The plots from the three actual narrowband passes and the narrowband data derived from the wideband pass were compared by "eyeball" correlation to see if they were generally similar. It was found that all the signatures had generally similar characteristics. Figures 5 and 6 show segments of two of these signatures The similarities and differences are quite reasonable for two different passes of the same satellite as seen at a radar frequency of 10.0 GHz. One other characteristic that could be seen but not quantified was the match-up of the segments of the derived signature at the ends of the individual images. The 18 images gave 17 junctions of which three had a relatively long gap between the end of one image's data and the beginning of the next, eleven had short gaps and three had overlapping data. In the cases of short gaps or overlaps, the excellent continuity and retracing of the signature plot was an indication that the signature segments were independent of the individual images and that there were no significant effects at the ends of the segments of the signature. Although these two observations did not directly validate the derived signature, they did indirectly add credence in a double negative sense: the signature did not show a problem.

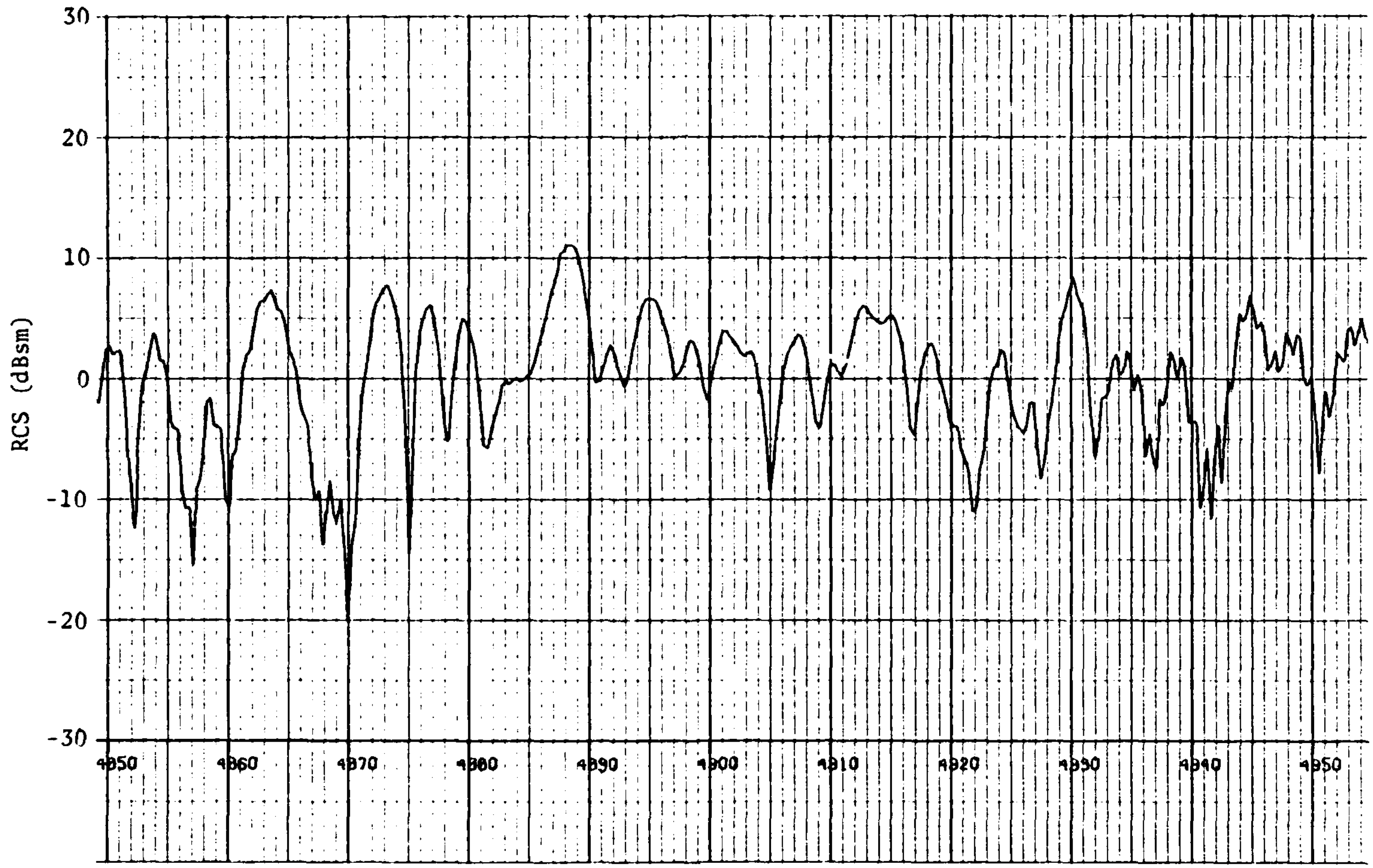


Figure 5 PORTION OF NARROWBAND SIGNATURE OF OBJECT 10352 AT 10.0 GHz

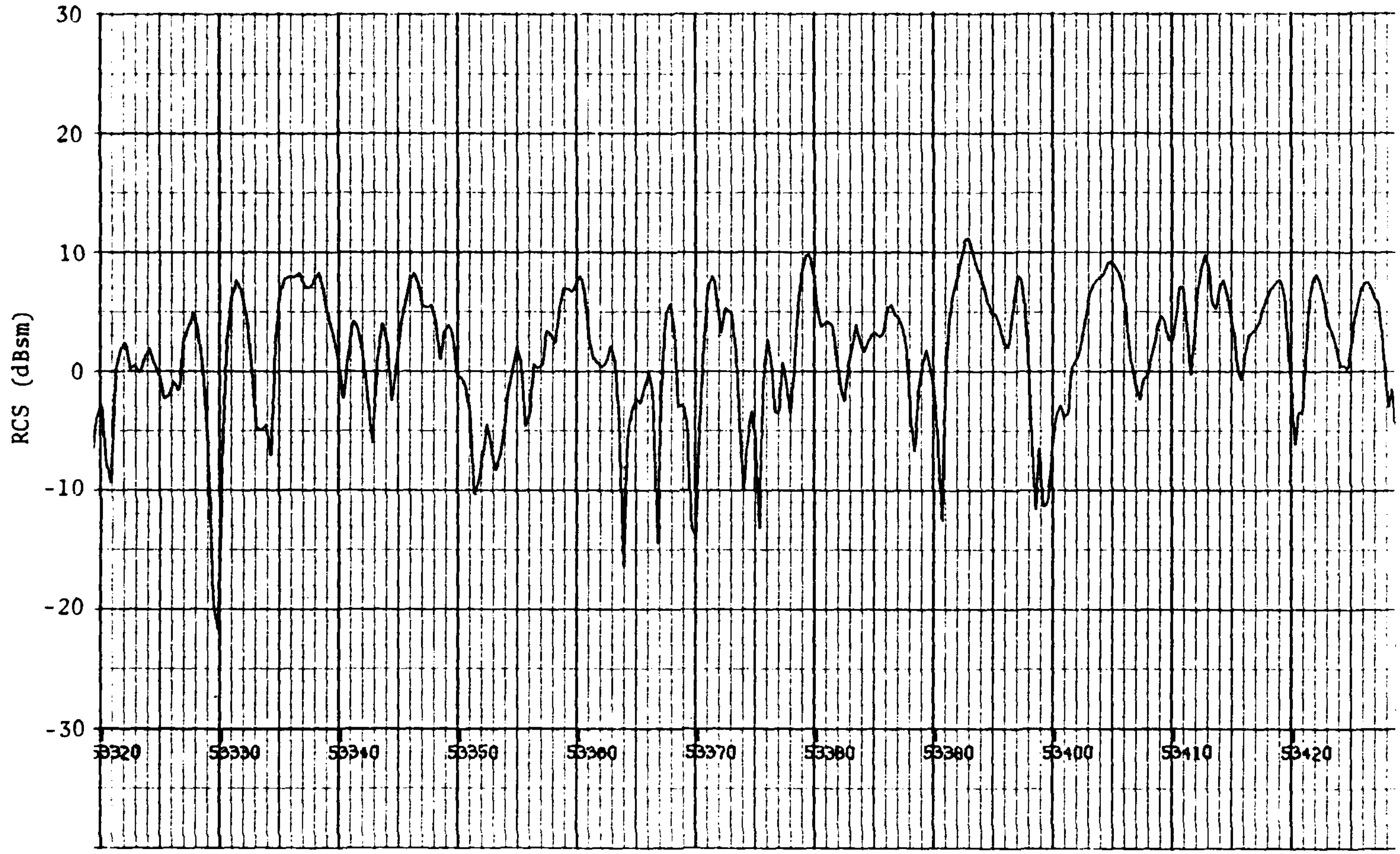


Figure 6 PORTION OF DERIVED NARROWBAND SIGNATURE OF OBJECT 10352 AT 10.0 GHz

Analysis of the signature statistics led to a more positive indication of the validity of the derived signature. Table 2 shows several statistics that compare the derived signature to the three actual signatures. Clearly, the derived signature fits well with the actual signatures, considering the variation among the actual signatures. The other statistic available for comparison was the distribution of RCS values over the signatures. The normalized distributions are shown in Figure 7, and the corresponding cumulative distributions are shown in Figure 8. Again, the derived signature fits well within the bounds established by comparison of the actual narrowband signatures.

TABLE 2

COMPARISON OF ACTUAL AND DERIVED RCS SIGNATURES

Pass	Mean RCS	Standard Deviation of RCS	Maximum RCS	Minimum RCS
Actual Narrowband 11/8/78	1.3	5.7	12	-25
Actual Narrowband 11/9/78	-1.5	5.9	11	-27
Actual Narrowband 11/8/78	0.9	5.6	12	-23
Derived from Wideband 11/7/78	1.4	5.4	13	-25

The major conclusion that can be drawn from this investigation is that, theoretically and practically, narrowband signatures derived from wideband data are a very good representation of actual narrowband signatures. The most important restriction is that the signal-to-noise ratio (SNR) of the derived signature is lower than the original wideband SNR by the ratio of the bandwidths, if the wideband signal spectrum is flat, as is typical. There is no restriction on the complexity or number of radar scatterers of the target.

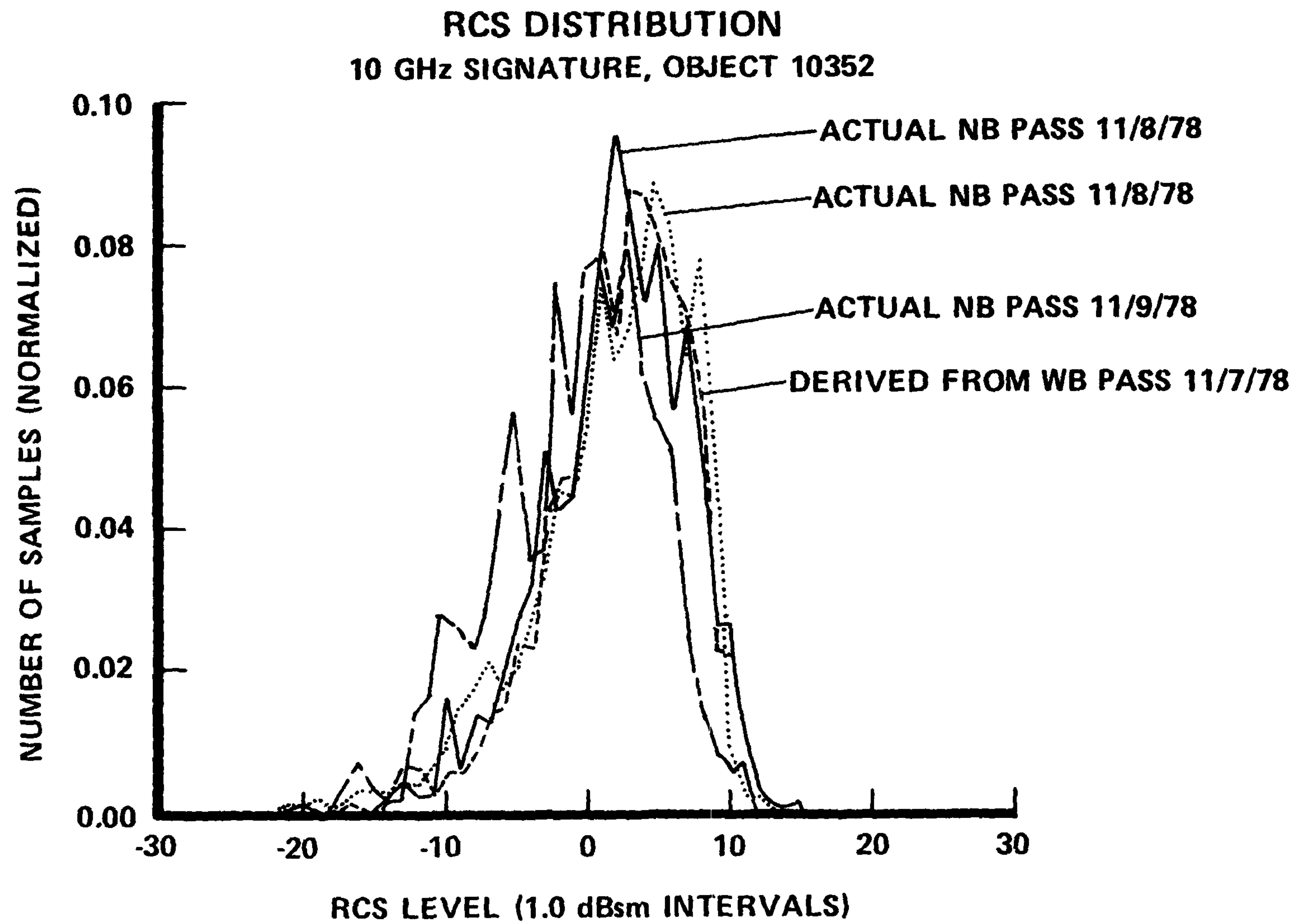


Figure 7 RCS DISTRIBUTION

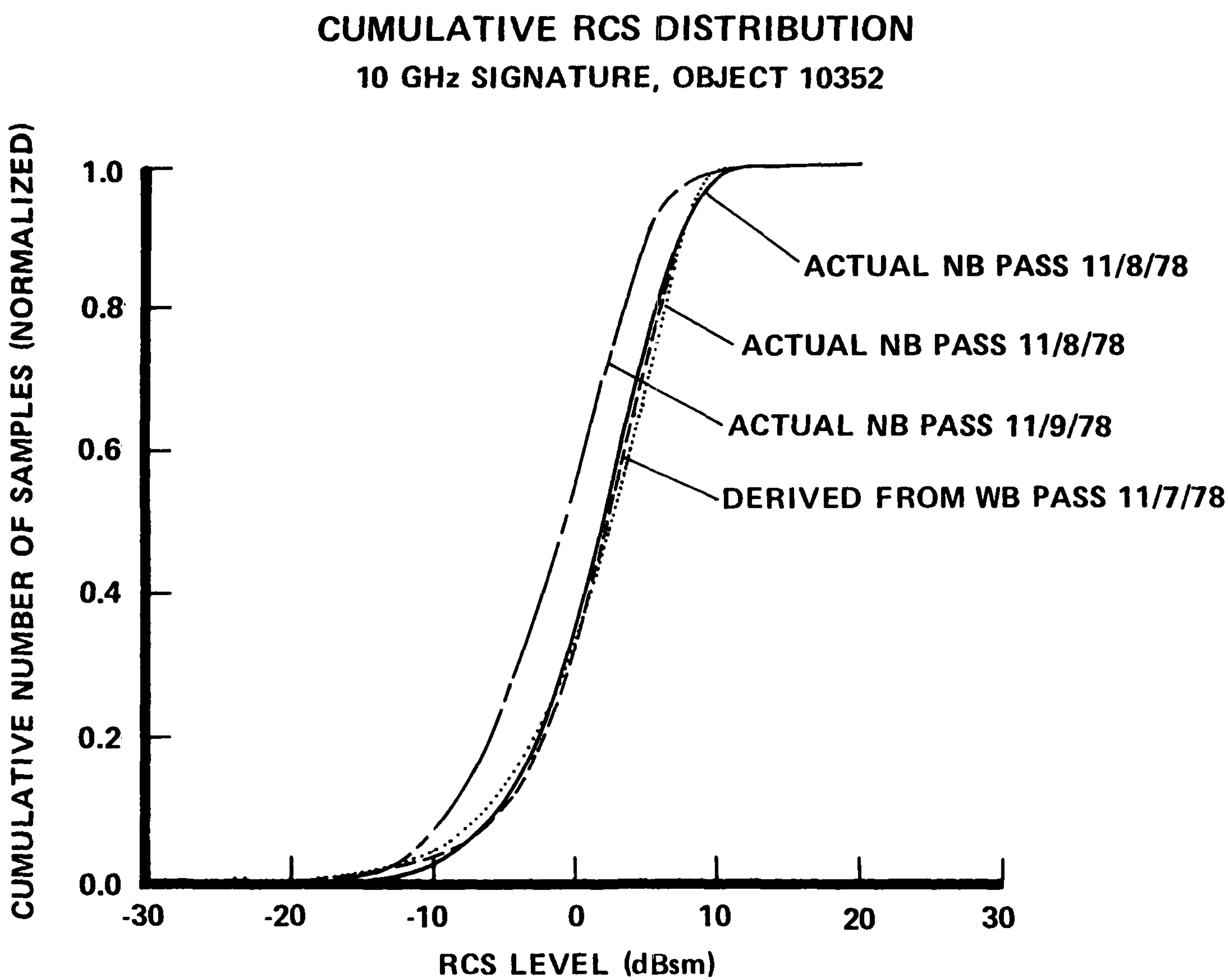


Figure 8 CUMULATIVE RCS DISTRIBUTION

The value of this capability to derive narrowband information from wideband data is multifold. 1) Narrowband data can be obtained without the necessity of modifying a wideband radar transmitter and receiver. 2) Narrowband data at multiple frequencies can be obtained simultaneously from the wideband data, permitting different radars and/or frequency-agile radars to be compared under identical geometric conditions and with real rather than simulated data. An example of a return at a second frequency is given in Figure 9; the sample corresponds to that shown in Figure 6. 3) Although not specifically discussed here, phase coherence is not lost in this filtering process, which means that coherent waveforms can be evaluated using data derived by this process.

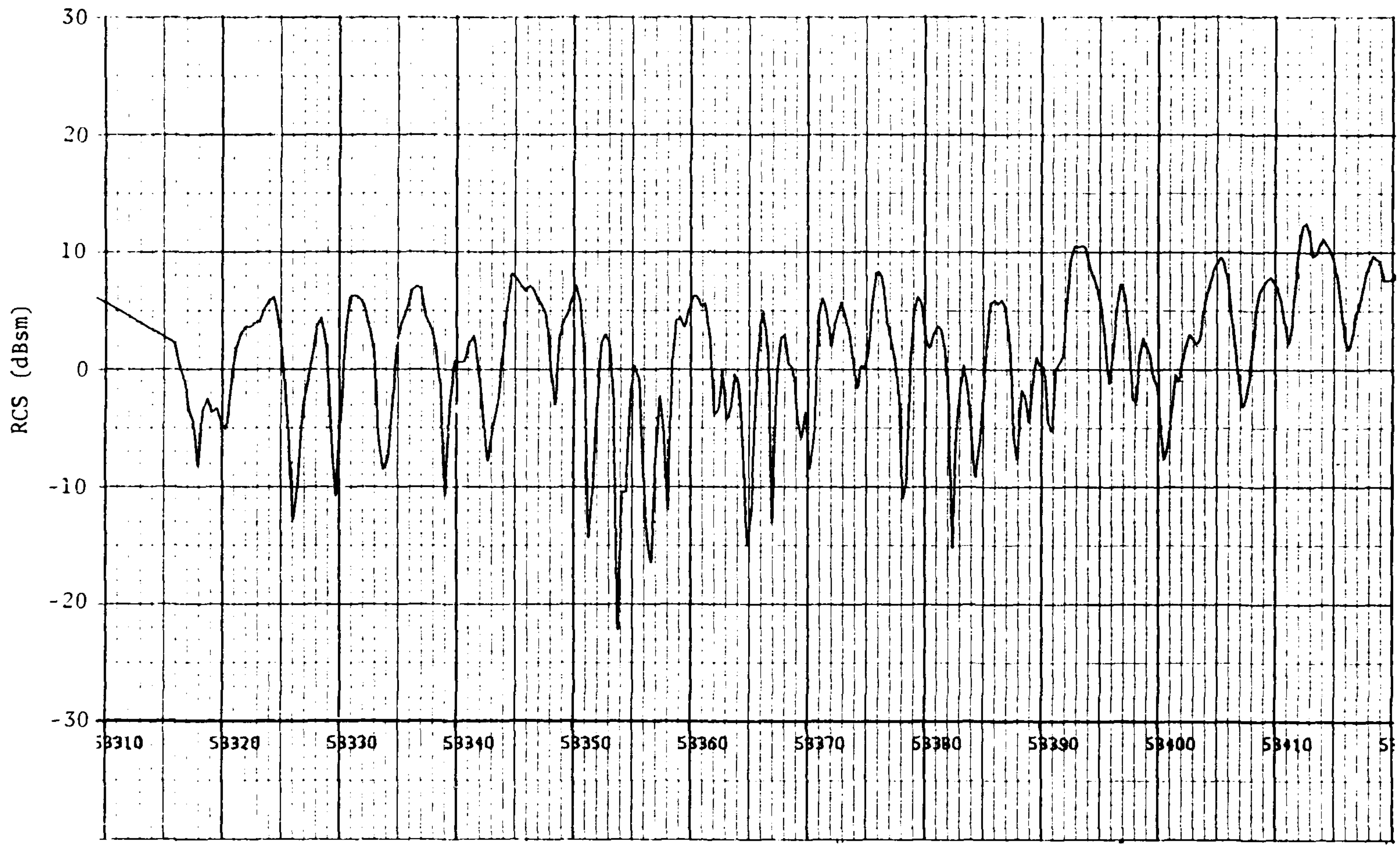


Figure 9 PORTION OF DERIVED NARROWBAND SIGNATURE OF OBJECT 10352 AT 10.032 GHz

APPENDIX A

DERIVATION OF NARROWBAND SIGNALS FROM WIDEBAND SIGNALS

This appendix shows that narrowband radar returns can be derived from wideband returns by a simple filtering operation. This is done by showing that the output from filtering a wideband return is identical to the output that would have been obtained if the radar had transmitted and received a narrowband signal.

A wideband signal S(t) is transmitted; it has the form:

$$S(t) = \sqrt{2\, E_T}\, g(t) \cos \left[2\pi f_0 t + \phi(t)\right]$$

where $\int_{-\infty}^{\infty} f^2(t)\, dt = 1$

E_T = transmitted signal energy

$g(t)$ = amplitude modulation function

$\phi(t)$ = phase modulation function

and f_0 = RF frequency

The signal is reflected from a point target and the return can be represented as:

$$r(t) = \beta \sqrt{2\, E_T}\, g(t) \cos \left[2\pi (f_0 + f_D)\, t + \phi(t)\right] + n(t)$$

where β = channel attenuation

f_D = Doppler frequency shift

$n(t)$ = zero mean white Gaussian noise with spectral density $\frac{1}{2} N_0$

Here it is assumed that the target moves no more than a small fraction of a range resolution cell during the coherent duration of the waveform. If this

is not true, as with the Haystack radar looking at satellites, a simple correction is made to compensate for the known Doppler shift.

The frequency spectrum (amplitude only) of the signal portion of this return, $S(f)$, is shown in Figure A1 (positive frequency only) with the noise power spectral density, $P_{SDN}(f)$, shown below it. The combined signal plus noise return is supplied to a matched filter in the receiver which effectively multiplies the frequency spectrum of the signal $S_0(f)$ by $S_0^*(f)$ and the noise power spectrum density is multiplied by $S_0(f)$

where:

$$S_0(f+f_D) = \sqrt{2} \int_{-\infty}^{\infty} g(t) \cos\left[2\pi(f_0+f_D)t + \phi(t)\right] e^{-j2\pi ft} \, dt$$

The spectrum at the output of the matched filter may be considered as the combination of signal and noise related terms:

$|S_0(f)|^2$ and $P_{SDN0}(f)$, respectively, and are shown in Figure A2.

Now assume that this signal is next applied to an ideal filter with center frequency f_C and bandwidth B. The signal spectrum portion of the output of this filter is:

$$\begin{aligned} |\hat{S}_0(f)|^2 &= |S(f)|^2 \text{ for } |f+f_C| \leq B/2 \\ &\qquad \text{and } |f-f_C| \leq B/2 \\ &= 0 \quad \text{otherwise} \end{aligned}$$

and the noise power spectrum portion is:

$$\begin{aligned} \hat{P}_{SDN0}(f) = P_{SDN0}(f) &= \frac{N_0}{2} |S(f)|^2 \text{ for } |f+f_0| \leq B/2 \\ &\qquad \text{and } |f-f_0| \leq B/2 \\ &= 0 \quad \text{otherwise} \end{aligned}$$

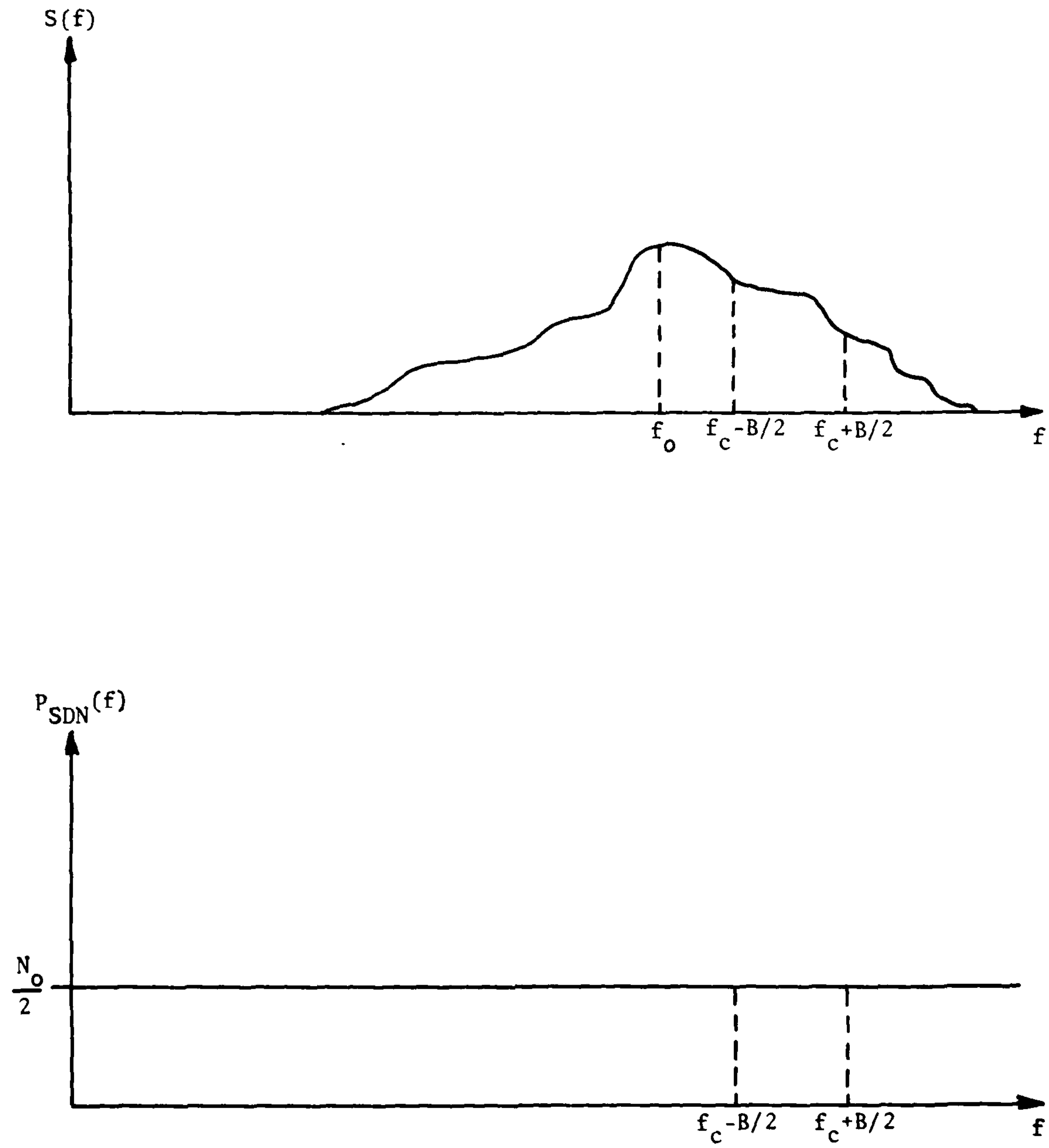
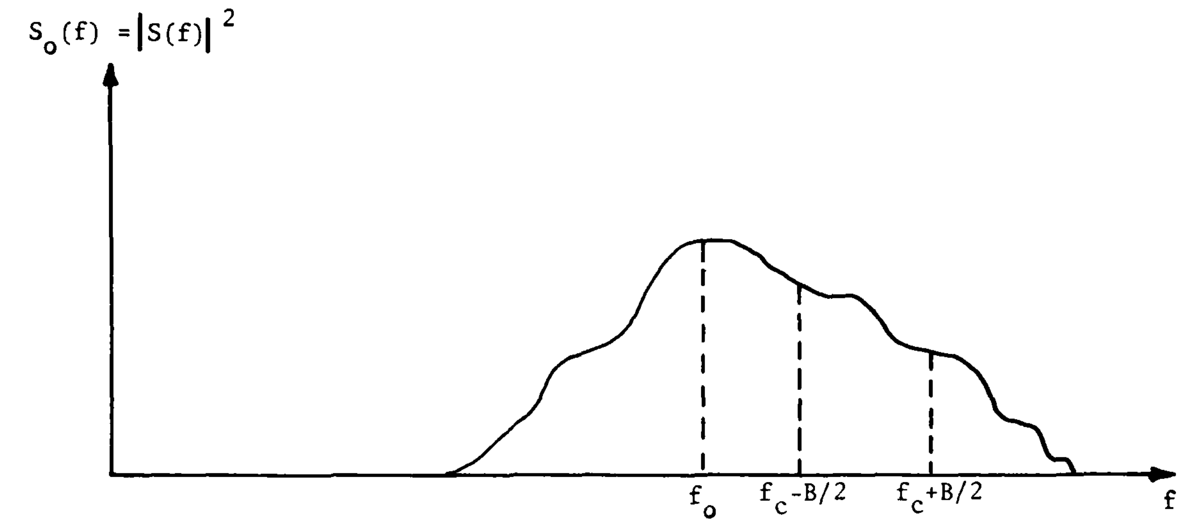


Figure A.1 PREFILTER SIGNAL SPECTRUM AND NOISE POWER SPECTRAL DENSITY



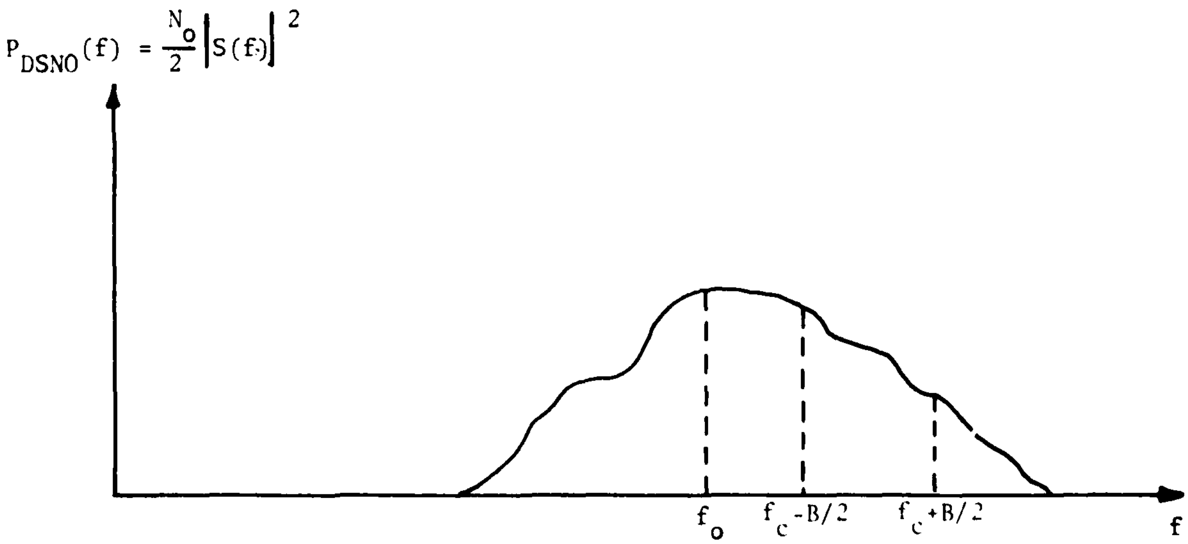


Figure A.2 POSTFILTER SIGNAL SPECTRUM AND NOISE POWER SPECTRUM

This return from the ideal filter is equivalent to the output of the matched filter if the input signal was originally

$$\hat{S}(t) = 2 \text{ Re } \{ \int_{f_0-B/2}^{f_0+B/2} S_0(f) \, e^{j2\pi ft} \, df \}$$

It is exactly the return that would have resulted if a narrowband signal (frequencies from f_0-B/2 to f_0+B/2) had been transmitted and received. In other words, filtering a wideband return after receiving will obtain the same result as transmitting and receiving a narrowband signal.

APPENDIX B

SOFTWARE DESCRIPTION AND USERS'GUIDE

I. Physical Characteristics

Tape #AXDSRC is a 9-track, non-labeled, 800 BPI tape with the following DCB information: RECFM=FB, LRECL=80, and BLKSIZE=8000. It is IBM compatible and contains 3 files.

II. Format

Each record on the tape is a card image of 80 characters and may be read in the same manner used to read a deck of cards.

III. Contents

The content of each file is as follows:

1. File 1

This file contains the software used to derive the narrowband data from the wideband coherent images. It includes a main driver, a block data routine, processing routines and output routines. The prologues (including inputs and outputs) are given in Table B1. Below is a brief description of each:

A) MATH - reads inputs and controls program flow through the processing and output routines.

B) BLOCK - a block data to initialize constants in common /LORINF/ for ladder plots.

C) Processing routines:

INV1 - performs an inverse Fourier transform on complex image data in the cross-range direction to generate wideband pulse shapes.

INV2 - performs an inverse Fourier transform on the complex pulse shapes to generate frequency spectra.

KAISER - generates a set of Kaiser weights for the frequency spectra.

PRDIST - calculates the mean, standard deviation, minimum, maximum, frequencies of occurrence and cumulative distribution of a set of data.

D) Output Routines:

LORINI, LDRPLT, PLT - initializes for and generates the side-band ladder plots.

MAGPLT - generates a printer plot of the magnitudes of a 2-dimensional image.

OUT1 - generates a listing of data statistics calculated in subroutine PRDIST.

E) The following are routines referenced in this program but not included on this tape due to particular machine dependency:

FOURT - performs Cooley-Tukey Fast Fourier Transform

CORE - allows use of I/O statements to perform conversions on a variable list into core instead of to/from an I/O device

CTIME2, DATE, JBNAME - returns time-of-day, date and name of job into core

PLOT, SYMBOL, NUMBER, EFPLOT - Calspan basic plot software

PLTTME - see File 3.

2. File 2

This file contains the software used to convert raw wideband radar data into 2-dimensional contour images. The software is composed of a main

driver/processing routine and a contour plot subroutine. The prologues describing each routine and its usage are given in Table B2. Below is a brief description of each:

A) IMAG2 - reads input data from tape and cards, processes the data for plotting, calls contour subroutine and then writes identifying information on contour image.

B) MCCNTR - the contour plot subroutine, employs Calspan's basic plot software (PLOT, AXIS, SYMBOL, NUMBER) to generate the 2-dimensional contour images.

3. File 3

This file contains the software used to process narrowband radar data and output results in the form of plots and statistical summaries. The software is composed of a main driver, processing routines and output routines. A brief description of each routine will be given below, while the prologues describing each program can be found in Table B3.

A) NBAND - reads parameter cards, advances tape to initial position, controls flow through processing and output routines.

B) Processing Routines:

SMOOTH - reads narrowband tape of RCS data in dBsm units, converts to square meters and calculates average RCS for the user selected number of data points.

CONVRT - converts an array of RCS data points from square meters to dBsm.

PRDIST - calculate the mean, standard deviation, minimum, maximum, and distribution of a set of data.

C) Output Routines:

OUT1 - outputs to the printer the statistics calculated in PRDIST

PLTTIME - outputs narrowband plot of RCS vs time.

PLTASP - outputs narrowband plot of RCS vs aspect angle or projected aspect angle.

Note: As pointed out in File 1 description, the programs on both File 2 and File 3 call for Calspan's basic plot package composed of PLOT, AXIS, SYMBOL, NUMBER,--which have not been included on this tape due to particular machine dependency.

TABLE B1

PROLOGUES TO ROUTINES ON FILE 1

```
CC****************************  MAIN  **********************************
CC*                                                                     *
CC*                                                                     *
CC*                                                                     *
CC*     PURPOSE                                                         *
CC*          TO DERIVE NB DATA FROM WB DATA THROUGH INVERSE FOURIER TRANS-*
CC*          FORMS.                                                     *
CC*                                                                     *
CC*     METHOD                                                          *
CC*          AN INVERSE FOURIER TRANSFORM IS PERFORMED ON THE COMPLEX   *
CC*          IMAGE IN THE CROSS-RANGE DIRECTION FOR EACH RANGE GATE     *
CC*          REQUESTED, THIS GENERATES THE ORIGINAL WB PULSE SHAPES. AN *
CC*          INVERSE FFT IS THEN DONE ON EACH PULSE SHAPE TO GENERATE   *
CC*          FREQUENCY SPECTRA. VARIOUS TAPE, LIST AND PLOTS ARE PRODUCED *
CC*          AT EACH STAGE OF THE PROCESSING. FINALLY, STATISTICS ARE DONE*
CC*          ON A SINGLE FREQUENCY (IFSTAT).                            *
CC*                                                                     *
CC*     PROGRAM INPUTS:                                                 *
CC*          TAPES - UNIT 1:  WB COMPLEX IMAGE TAPE FROM LL             *
CC*          CARDS - UP TO 3 NAMELISTS ARE READ:                        *
CC*                  &INPUT1 - REQUIRED                                 *
CC*                    NGATE1 - FIRST RANGE GATE IN IMAGE TO BE PROCESSED *
CC*                    NGATES - NUMBER OF GATES TO BE PROCESSED (MUST BE *
CC*                             DIVISIBLE BY 4)                        *
CC*                    NIMAGS - NUMBER OF IMAGES TO PROCESS             *
CC*                    SLL    - SIDELOBE LEVEL(DB) FOR WEIGHTING        *
CC*                    MGPLTS- LOG. INDICATOR FOR MAGNITUDE PLOTS OF THE *
CC*                             IMAGE, WB PULSES & FREQ(FOR EACH IMAGE) *
CC*                    WBLDR - LOGICAL INDICATOR FOR WB LADDER PLOT     *
CC*                    WBTAPE- LOG. INDICATOR FOR WB PULSE SHAPE TAPE.  *
CC*                    WBLST - LOG. INDICATOR FOR DIAG. LIST OF 1 PULSE *
CC*                    IPLIST- PULSE NUMBER TO BE LISTED                *
CC*                    NBPLT - LOG. INDICATOR FOR NB RCS VS. TIME PLOT  *
CC*                    NBTAPE- LOG. INDICATOR FOR NB FREQUENCY TAPE     *
CC*                    NBLST - LOG. INDICATOR FOR DIAG. LIST OF 1 FREQ. *
CC*                    IFLIST- FREQ NUMBER TO BE LISTED                 *
CC*                    IFPLOT- FREQ NUMBER TO BE PLOTTED ON RCS PLOT    *
CC*                    IFSTAT- FREQ NUMBER FOR STATISTICS               *
CC*                    RCSL   - LOW BIN RCS VALUE FOR HISTOGRAM         *
CC*                    RCSR   - HIGH BIN RCS FOR HIST.                  *
CC*                    RCSINC- RCS INCREMENT FOR HIST.                  *
CC*                    CALIB  - CALIBRATION FACTOR FOR FREQ DATA        *
CC*                  &LDRIN - READ ONLY IF WBLDR=T                      *
CC*                    XLEFT,XRIGHT,XLEN,YBOT,YTOP,YLEN,LABREP,RUNGSP   *
CC*                    **FOR DESCRIPTION OF THESE SEE COMMON LDRINF BELOW *
CC*                  &TMEPLT - READ (BY SUBROUTINE PLTTME) ONLY IF NBPLT=T*
CC*                    RCSLNG- LENGTH(IN) OF RCS(Y) AXIS                *
CC*                    RCSSCL- INCREMENT PER INCH (DB) FOR RCS          *
CC*                    TMESCL- INCREMENT PER INCH(SEC) FOR TIME(X) AXIS *
CC*                    TAPEID- TITLE TO BE PLACED ON RCS PLOT           *
CC*                    RCSTTL- TITLE FOR RCS AXIS                       *
CC*                    RCSMIN- MIN. VALUE FOR RCS                       *
CC*                                                                     *
CC*     PROGRAM OUTPUTS:                                                *
CC*          TAPES - UNIT 2: WB PULSE SHAPES (IF WBTAPE=T)              *
CC*                  UNIT 3: DERIVED NB DATA FOR ALL FREQUENCIES (IF NBTAPE
CC*                                                               =T) *
CC*          PLOTS - 2 POSSIBLE (NOT BOTH IN 1 RUN):                    *
CC*                  1) WB PULSE SHAPE LADDER PLOT (IF WBLDR=T)         *
CC*                  2) NB RCS VS. TIME PLOT FOR FREQ # IFPLOT (IF NBPLT=T)
CC*          LISTS - PRINTER PLOTS OF MAGNITUDE(IF MGPLTS=T) OF:        *
CC*                     WB IMAGES, WB PULSES AND NB FREQUENCIES         *
CC*                  DIAG. LIST OF PULSE # IPLIST (IF WBLST=T)          *
CC*                  DIAG. LIST OF FREQ # IFLIST (IF NBLST=T)           *
CC*                  STATISTICAL RESULTS FOR EACH IMAGE                 *
CC*                                                                     *
CC*     COMMON VARIABLES USED                                           *
CC*          /LDRINF/ - VARIABLES USED FOR WB LADDER PLOT               *
CC*                                                                     *
CC*     REMARKS                                                         *
CC*          - TO PRODUCE A WB LADDER PLOT, PLOTTER=CALCOMP,LONG=V,     *
CC*            PAPER=SG SHOULD BE SPECIFIED ON THE EXEC CARD            *
CC*          - TO PRODUCE A NB RCS PLOT, PLOTTER=CALCOMP,LONG=X,PAPER=SG *
CC*            SHOULD BE USED                                           *
CC*          - AT THIS TIME, THE PROGRAM CAN DO EITHER THE LADDER PLOT OR *
CC*            THE RCS PLOT, NOT BOTH                                   *
```

TABLE B1

PROLOGUES TO ROUTINES ON FILE 1 (CONT.)

```
CC*                                                                              *
CC*   SUBROUTINE AND FUNCTION SUBPROGRAMS REQUIRED                               *
CC*       CTIME2,DATE,EFPLOT,JBNAME - CALSUBS                                    *
CC*       KAISER                                                                 *
CC*       INV1,INV2,LDRINI,LDRPLT,PRDIST,OUT1,PLTTME - STORED ON PRIVATE         *
CC*                  DISKLIB 'LCMD.DISKLIB'                                      *
CC*                                                                              *
CC*   AUTHOR/PROGRAMMER                                                          *
CC*       C.M.SZCZESNY                                                           *
CC*       MAR 1979                                                               *
CC*                                                                              *
CC********************************************************************************
CC*****************************   BLOCK   ****************************************
CC*                                                                              *
CC*                          SUBROUTINE BLOCK                                    *
CC*                                                                              *
CC*   PURPOSE                                                                    *
CC*       TO INITIALIZE VARIABLES IN COMMON                                      *
CC*                                                                              *
CC*   COMMON VARIABLES USED                                                      *
CC*       VARIABLES ARE INITIALIZED IN THE FOLLOWING COMMONS:                    *
CC*         LDRINF                                                               *
CC*                                                                              *
CC*   AUTHOR/PROGRAMMER                                                          *
CC*       C.M.SZCZESNY                                                           *
CC*       MAR 1979                                                               *
CC*                                                                              *
CC********************************************************************************
CC*****************************   INV1   *****************************************
CC*                                                                              *
CC*                          SUBROUTINE INV1                                     *
CC*                                                                              *
CC*   PURPOSE                                                                    *
CC*       TO PERFORM AN INVERSE FOURIER TRANSFORM ON COMPLEX IMAGE               *
CC*       DATA IN THE CROSS-RANGE DIRECTION, TO GENERATE WB PULSE                *
CC*       SHAPES.                                                                *
CC*                                                                              *
CC*   CALLING SEQUENCE                                                           *
CC*       CALL INV1 (V,NF,NG,NTOL)                                               *
CC*                                                                              *
CC*   DESCRIPTION OF PARAMETERS                                                  *
CC*       INPUTS:                                                                *
CC*         NF   - NO. OF CROSS-RANGE CELLS IN THE IMAGE                         *
CC*         NG   - NO. OF RANGE GATES IN THE IMAGE                               *
CC*         NTOL - ACTUAL NO. OF PULSES USED TO GENERATE THE IMAGE               *
CC*       HYBRIDS:                                                               *
CC*         V    - COMPLEX ARRAY CONTAINING THE 2-DIMENSIONAL IMAGE              *
CC*                                                                              *
CC*   COMMON VARIABLES USED                                                      *
CC*       NONE                                                                   *
CC*                                                                              *
CC*   SUBROUTINE AND FUNCTION SUBPROGRAMS REQUIRED                               *
CC*       FOURT - CALSUBS FOURIER TRANSFORM ROUTINE                              *
CC*                                                                              *
CC*   AUTHOR/PROGRAMMER                                                          *
CC*       M.BURNS                                                                *
CC*       MAR 1979                                                               *
CC*                                                                              *
CC********************************************************************************
CC*****************************   INV2   *****************************************
CC*                                                                              *
CC*                          SUBROUTINE INV2                                     *
CC*                                                                              *
CC*   PURPOSE                                                                    *
CC*       TO PERFORM AN INVERSE FOURIER TRANSFORM ON COMPLEX IMAGE               *
CC*       DATA IN THE RANGE DIRECTION TO GENERATE FREQUENCY SPECTRA              *
CC*       FROM THE WB PULSE SHAPES.                                              *
CC*                                                                              *
CC*   CALLING SEQUENCE                                                           *
CC*       CALL INV2 (V,NF,NG,NTOL,WT2,CALIB)                                     *
CC*                                                                              *
CC*   DESCRIPTION OF PARAMETERS                                                  *
CC*       INPUTS:                                                                *
CC*         NF   - NO. OF CROSS-RANGE CELLS IN THE IMAGE                         *
CC*         NG   - NO. OF RANGE GATES IN THE IMAGE                               *
CC*         NTOL - ACTUAL NO. OF PULSES USED TO GENERATE THE IMAGE               *
CC*         WT2  - ARRAY OF WEIGHTS FOR THE RANGE DIMENSION                      *
CC*         CALIB-CALIBRATION FACTOR FOR SPECTRAL DATA                           *
CC*       HYBRIDS:                                                               *
CC*         V    - COMPLEX ARRAY CONTAINING THE 2-DIMENSIONAL IMAGE              *
CC*                                                                              *
CC*   COMMON VARIABLES USED                                                      *
CC*       NONE                                                                   *
CC*                                                                              *
CC*   SUBROUTINE AND FUNCTION SUBPROGRAMS REQUIRED                               *
CC*       FOURT - CALSUBS FOURIER TRANSFORM ROUTINE                              *
```

TABLE B1

PROLOGUES TO ROUTINES ON FILE 1 (CONT.)

```
CC*                                                                          *
CC*   AUTHOR/PROGRAMMER                                                      *
CC*        M.BURNS                                                           *
CC*        MAR 1979                                                          *
CC*                                                                          *
CC************************************************************************ ***
CC**************************** KAISER ****************************** ***
CC*                                                                          *
CC*                        SUBROUTINE KAISER                                 *
CC*                                                                          *
CC*   PURPOSE                                                                *
CC*        GENERATES A SET OF KAISER WEIGHTS.                                *
CC*                                                                          *
CC*   CALLING SEQUENCE                                                       *
CC*        CALL KAISER (N,SLL,BUF,  IER)                                     *
CC*                                                                          *
CC*   DESCRIPTION OF PARAMETERS                                              *
CC*        INPUTS:                                                           *
CC*          N    - NUMBER OF SAMPLES                                        *
CC*          SLL  - DESIRED LEVEL OF SIDELOBES BELOW MAINLOBE IN DB(NEG.)
CC*        OUTPUTS:                                                          *
CC*          BUF  - ARRAY FOR WEIGHTS                                        *
CC*          IER  - ERROR FLAG                                               *
CC*                 IF NON-ZERO, THEN INPUT SLL WAS BAD AND DEFAULT          *
CC*                 WEIGHTING IS CHOSEN.                                     *
CC*                                                                          *
CC*   COMMON VARIABLES USED                                                  *
CC*        NONE                                                              *
CC*                                                                          *
CC*   SUBROUTINE AND FUNCTION SUBPROGRAMS REQUIRED                           *
CC*        NONE                                                              *
CC*                                                                          *
CC*   AUTHOR/PROGRAMMER                                                      *
CC*        M.BURNS                                                           *
CC*        MAR 1979                                                          *
CC*                                                                          *
CC************************************************************************ ***
CC**************************** PRDIST ****************************** ***
CC*                                                                          *
CC*                        SUBROUTINE PRDIST                                 *
CC*                                                                          *
CC*   PURPOSE                                                                *
C**       EVALUATION OF DATA STATISTICS                                      *
C**         1) MEAN VALUE                                                    *
C**         2) STANDARD DEVIATION                                            *
C**         3) MAXIMUM                                                       *
C**         4) MINIMUM                                                       *
C**         5) HISTOGRAM(FREQUENCIES OF OCCURRENCE)                          *
C**         6) CUMULATIVE DISTRIBUTION                                       *
CC*                                                                          *
CC*   CALLING SEQUENCE                                                       *
CC*       CALL PRDIST (X,NP,A,B,C,D,EX)                                      *
CC*                                                                          *
CC*   DESCRIPTION OF PARAMETERS                                              *
CC*       INPUTS:                                                            *
C**       X IS THE NAME FOR THE DATA ARRAY                                   *
C**       NP IS THE NUMBER OF DATA POINTS                                    *
C**       A,B,C,.... DEFINE CELL SIZES AS                                    *
C**          A(B)C(D)E - ( THAT IS, A TO C IN INCREMENTS OF SIZE B,          *
C**                        THEN TO E IN INCREMENTS OF SIZE D).               *
C**          FOR A(B)C, SET E=D=C OR SET E= 0.0.                             *
CC*                                                                          *
CC*   COMMON VARIABLES USED                                                  *
CC*        OUTPUTS:                                                          *
CC*       /LCPROB/ SEE DESC. OF PARAMETERS IN REMARKS                        *
CC*                                                                          *
CC*   REMARKS                                                                *
C**       RESULTS ARE LEFT IN LABELED COMMON LCPROB, DEFINED BY              *
C**       COMMON/LCPROB/ NBUCK(101),DIST(101),CELL1(102),XMAX,XMIN,          *
C**                      XBAR,DEV,K1,NX                                      *
C**       NBUCK(I) IS THE NO. OF OCCURRENCES(INTEGER) FOR THE ITH CELL.      *
C**       DIST(I) IS THE CUMULATIVE DISTRIBUTION(FLOATING POINT VALUE IN*
C**               INTERVAL 0.0 TO 1.0) CORRESPONDING TO THE RIGHT HAND       *
C**               EDGE OF THE ITH CELL.                                      *
C**       CELL1(I),CELL1(I+1) DEFINE THE LEFT AND RIGHT HAND EDGES,          *
C**               RESPECTIVELY, OF THE ITH CELL. (CELL1(1) IS SET TO         *
C**         -10**75 CELL1(K1+1)  IS SET TO 10**75 BY THE PROGRAM             *
C**       XMAX,XMIN ARE MAXIMUM AND MINIMUM X VALUES, RESPECTIVELY.          *
C**       XBAR IS THE COMPUTED AVERAGE VALUE FOR THE X S.                    *
C**       DEV IS THE COMPUTED STANDARD DEVIATION FOR THE X S.                *
C**       K1 IS THE NUMBER OF INTERVALS.                                     *
CC*       NX IS THE NUMBER OF DATA POINTS (=NP)                              *
```

TABLE B1

PROLOGUES TO ROUTINES ON FILE 1 (CONT.)

```
CC*                                                                         *
CC*        NOTE: A ROUTINE CALLED OUT1 (STORED ON 'LCMD.DISKLIB' AS          *
CC*              AXOUT1) CAN BE USED TO LIST THE RESULTS GENERATED BY        *
CC*              PRDIST.                                                     *
CC*                                                                         *
CC*     SUBROUTINE AND FUNCTION SUBPROGRAMS REQUIRED                          *
CC*         NONE                                                             *
CC*                                                                         *
CC*     AUTHOR/PROGRAMMER                                                    *
CC*         M.BURNS                                                          *
CC*         MAR 1979                                                         *
CC*                                                                         *
CC**************************************************************************
CC**************************** LDRINI ******************************
CC*                                                                         *
CC*                          SUBROUTINE LDRINI                               *
CC*                                                                         *
CC*     PURPOSE                                                              *
CC*         TO INITIALIZE FOR LADDER PLOTS BY DEFINING PAGE ORIGIN AND       *
CC*         WRITING LADDER LABEL WITH TITLE AND X,Y AXIS DESCRIPTORS.        *
CC*                                                                         *
CC*     CALLING SEQUENCE                                                     *
CC*         CALL LDRINI                                                      *
CC*                                                                         *
CC*     COMMON VARIABLES USED                                                *
CC*         INPUTS:                                                          *
CC*           /LDRINF/  XTAG,XUNITS,XLEFT,XRIGHT,XLEN,                       *
CC*                     YTAG,YUNITS,YBOT,YTOP,YLEN,TITLE,RUNGLB              *
CC*                                                                         *
CC*     SUBROUTINE AND FUNCTION SUBPROGRAMS REQUIRED                          *
CC*         PLOT,SYMBOL,CORE - CALSUBS                                       *
CC*                                                                         *
CC*     AUTHOR/PROGRAMMER                                                    *
CC*         C.M.SZCZESNY                                                     *
CC*         FEB 1979                                                         *
CC*                                                                         *
CC**************************************************************************
CC**************************** LDRPLT ******************************
CC*                                                                         *
CC*                          SUBROUTINE LDRPLT                               *
CC*                                                                         *
CC*     PURPOSE                                                              *
CC*         TO GENERATE A PLOT OF Y VS. X THAT WILL BE ONE RUNG IN A         *
CC*         LADDER OF SUCH PLOTS.                                            *
CC*                                                                         *
CC*     CALLING SEQUENCE                                                     *
CC*         CALL LDRPLT (X,Y,NPTS,RUNGID)                                    *
CC*                                                                         *
CC*     DESCRIPTION OF PARAMETERS                                            *
CC*         INPUTS:                                                          *
CC*           X       - ARRAY OF X DATA VALUES                               *
CC*           Y       - ARRAY OF Y DATA VALUES                               *
CC*           NPTS    - NUMBER OF POINTS IN X,Y TO BE PLOTTED                *
CC*           RUNGID- IDENTIFIER FOR THIS RUNG (SUCH AS TIME,RECORD #,ETC)
CC*                                                                         *
CC*     COMMON VARIABLES USED                                                *
CC*         INPUTS:                                                          *
CC*           /LDRINF/  XLEFT,XRIGHT,XLEN,YBOT,YTOP,YLEN,RUNGSP,LABREP       *
CC*                                                                         *
CC*     SUBROUTINE AND FUNCTION SUBPROGRAMS REQUIRED                          *
CC*         PLOT,NUMBER - CALSUBS                                            *
CC*         PLT         - DRAWS Y VS. X                                      *
CC*                                                                         *
CC*                                                                         *
CC*     REMARKS                                                              *
CC*         USAGE:                                                           *
CC*         USING SUBROUTINE LDRPLT REQUIRES LINKAGE OF 2 OTHER SUBROUTINE
CC*         LDRINI AND PLT (STORED AS GNLDRINI AND GNPLT ON LCMD.DISKLIB).
CC*         LDRINI MUST BE CALLED ONCE BEFORE 1ST CALL TO LDRPLT.            *
CC*         LDRPLT IS CALLED FOR EACH TRACE THAT IS TO BE A RUNG ON THE      *
CC*         LADDER PLOT. THE CALLING PROGRAM MUST THEN EXECUTE A CALL TO     *
CC*         EFPLOT (ON CALSUBS) AFTER ALL TRACES ARE PLOTTED.                *
CC*                                                                         *
CC*     AUTHOR/PROGRAMMER                                                    *
CC*         C.M.SZCZESNY                                                     *
CC*         FEB 1979                                                         *
CC*                                                                         *
CC**************************************************************************
```

TABLE B1

PROLOGUES TO ROUTINES ON FILE 1 (CONT.)

```
CC****************************  PLT  ********************************
CC*                                                                  *
CC*                        SUBROUTINE PLT                            *
CC*                                                                  *
CC*   PURPOSE                                                        *
CC*      TO PLOT THE (X,Y) COORDINATES AND CLIP THOSE LINES THAT ARE *
CC*      ABOVE AND BELOW THE PLOT BOUNDARIES.                        *
CC*                                                                  *
CC*   CALLING SEQUENCE                                               *
CC*      CALL PLT (X,Y,NPTS,XMIN,XMAX,XSPAN,YMIN,YMAX,YSPAN)         *
CC*                                                                  *
CC*   DESCRIPTION OF PARAMETERS                                      *
CC*      INPUTS:                                                     *
CC*         X      - ARRAY OF X DATA VALUES                          *
CC*         Y      - ARRAY OF Y DATA VALUES                          *
CC*         NPTS   - NUMBER OF POINTS IN X,Y TO BE PLOTTED           *
CC*         XMIN   - MINIMUM VALUE FOR X-AXIS                        *
CC*         XMAX   - MAXIMUM VALUE FOR X-AXIS                        *
CC*         XSPAN  - LENGTH(INCHES) OF X-AXIS                        *
CC*         YMIN   - MINIMUM VALUE FOR Y-AXIS                        *
CC*         YMAX   - MAXIMUM VALUE FOR Y-AXIS                        *
CC*         YSPAN  - LENGTH(INCHES) OF Y-AXIS                        *
CC*                                                                  *
CC*   COMMON VARIABLES USED                                          *
CC*      NONE                                                        *
CC*                                                                  *
CC*   SUBROUTINE AND FUNCTION SUBPROGRAMS REQUIRED                   *
CC*      PLOT - CALSUBS                                              *
CC*                                                                  *
CC*   AUTHOR/PROGRAMMER                                              *
CC*      C.M.SZCZESNY                                                *
CC*      FEB 1979                                                    *
CC*                                                                  *
CC********************************************************************
```

```
CC****************************  MAGPLT  *****************************
CC*                                                                  *
CC*                        SUBROUTINE MAGPLT                         *
CC*                                                                  *
CC*   PURPOSE                                                        *
CC*      TO GENERATE A PRINTER PLOT OF THE MAGNITUDES OF A 2-DIMENSION*
CC*      IMAGE                                                       *
CC*                                                                  *
CC*   CALLING SEQUENCE                                               *
CC*      CALL MAGPLT (V,NROW,NCOL,VSCALE,VTH)                        *
CC*                                                                  *
CC*   DESCRIPTION OF PARAMETERS                                      *
CC*      INPUTS:                                                     *
CC*         V      - ARRAY CONTAINING THE IMAGE                      *
CC*         NROW   - 1ST DIMEN. OF V (#ELEMENTS IN CROSS-RANGE DIRECTION)
CC*         NCOL   - 2ND DIMEN. OF V (#ELEMENTS IN RANGE DIRECTION)  *
CC*         VSCALE- SCALE FACTOR FOR V                               *
CC*         VTH    - THRESHOLD TO BE USED ON V                       *
CC*                                                                  *
CC*   COMMON VARIABLES USED                                          *
CC*      NONE                                                        *
CC*                                                                  *
CC*   SUBROUTINE AND FUNCTION SUBPROGRAMS REQUIRED                   *
CC*      NONE                                                        *
CC*                                                                  *
CC*   AUTHOR/PROGRAMMER                                              *
CC*      M.BURNS                                                     *
CC*      MAR 1979                                                    *
CC*                                                                  *
CC********************************************************************
```

TABLE B1

PROLOGUES TO ROUTINES ON FILE 1 (CONT.)

```
CC****************************** OUT1 ***********************************
CC*                                                                     *
CC*                         SUBROUTINE OUT1                             *
CC*                                                                     *
CC*   PURPOSE                                                           *
C**       PRINT OUTPUT OF DATA STATISTICS FROM SUBROUTINE PRDIST        *
CC*                                                                     *
CC*   CALLING SEQUENCE                                                  *
CC*       CALL OUT1                                                     *
CC*                                                                     *
CC*   COMMON VARIABLES USED                                             *
CC*       INPUTS:                                                       *
CC*         /LCPROB/                                                    *
CC*           NBUCK - NO. OF OCCURRENCES FOR EACH CELL                  *
CC*           DIST  - CUMMULATIVE DISTRIBUTIONS CORRESPONDING TO RIGHT  *
CC*                     HAND EDGE OF EACH CELL                          *
CC*           CELL1 - DEFINES THE EDGES OF THE CELLS FROM RIGHT TO LEFT *
CC*           XMAX  - MAXIMUM VALUE                                     *
CC*           XMIN  - MINIMUM VALUE                                     *
CC*           XBAR  - COMPUTED AVERAGE                                  *
CC*           DEV   - COMPUTED STANDARD DEVIATION                       *
CC*           K1    - NO. OF INTERVALS                                  *
CC*           NX    - NO. OF DATA POINTS                                *
CC*                                                                     *
CC*   REMARKS                                                           *
C**       SAMPLE PRINT OUT COULD LOOK LIKE THIS.                        *
C**      MEAN= 11.42 SIGMA= 8.6236 MAX.= 30.00 MIN= 1.00  NO. PTS.=200  *
C**           CELL        FREQ.   CUM.             CELL         FREQ.   CUM. *
C**       ***** -    0.        0   0.          10.00 -  12.00     20  60.00 *
C**        0.   -    1.00      0   0.          12.00 -  14.00     10  65.00 *
C**        1.00 -    2.00     20  10.00        14.00 -  16.00     10  70.00 *
C**        2.00 -    3.00     10  15.00        16.00 -  18.00     20  80.00 *
C**        3.00 -    4.00     10  20.00        18.00 -  20.00     10  85.00 *
C**        4.00 -    5.00     10  25.00        20.00 -  22.00      5  87.50 *
C**        5.00 -    6.00     10  30.00        22.00 -  24.00      0  87.50 *
C**        6.00 -    7.00     10  35.00        24.00 -  26.00      5. 90.00 *
C**        7.00 -    8.00     10  40.00        26.00 -  28.00      0  90.00 *
C**        8.00 -    9.00     10  45.00        28.00 -  30.00      0  90.00 *
C**        9.00 -   10.00     10  50.00        30.00 - ******     20 100.00 *
C**                                                                     *
C**      A SKIP TO A NEW SHEET PLUS A HEADER LINE SHOULD BE SUPPLIED    *
C**      BY THE USER IN THE MAIN CALLING PROGRAM.                       *
CC*                                                                     *
CC*   SUBROUTINE AND FUNCTION SUBPROGRAMS REQUIRED                      *
CC*       NONE                                                          *
CC*                                                                     *
CC*   AUTHOR/PROGRAMMER                                                 *
CC*       BURNS/SZCZESNY                                                *
CC*       MAR 1979                                                      *
CC*                                                                     *
CC***********************************************************************
```

TABLE B2

PROLOGUES TO ROUTINES ON FILE 2

```
CC*************************************************************************
CC*                                                                       *
CC*                          ** IMAG2 **                                  *
CC*                                                                       *
CC*               X-BAND CONTOUR PLOT PROGRAM                             *
CC*                                                                       *
CC*   PURPOSE                                                             *
CC*        TO READ A TAPE OF WIDEBAND RADAR DATA, CONVERT                 *
CC*        THESE DATA INTO MAGNITUDE VALUES AND PRODUCE TWO               *
CC*        DIMENSIONAL CONTOUR IMAGES OF THE CONVERTED DATA               *
CC*                                                                       *
CC*   INPUTS                                                              *
CC*     CARDS:                                                            *
CC*        VARIABLES TO CONTROL READING,PRINTING, PLOTTING                *
CC*       METHOD:                                                         *
CC*        3 NAMELIST STATEMENTS AND 1 FORMATTED READ STATEMENT ARE       *
CC*        USED TO INPUT PARAMETERS AS SHOWN BELOW:                       *
CC*                                                                       *
CC*         NAMELIST /DOINDX/ - PARAMETERS TO CONTROL READING OF          *
CC*                             THE INPUT TAPE                            *
CC*           NREC1   - THE RECORD NUMBER (POSITION) OF THE INITIAL       *
CC*                     RECORD TO BE READ FOR EACH IMAGE                  *
CC*           NREC2   - THE RECORD NUMBER (POSITION) OF THE LAST          *
CC*                     RECORD TO BE READ FOR EACH IMAGE                  *
CC*           NIMAGS  - THE TOTAL NUMBER OF IMAGES ON THE TAPE            *
CC*           NIMAGP  - THE NUMBER OF THESE IMAGES TO BE PROCESSED        *
CC*                     DURING THIS RUN                                   *
CC*         FORMATTED READ (1000) - PARAMETER TO CONTROL WHICH IMAGES     *
CC*                                 ARE PLOTTED. USED IN CONJUNCTION      *
CC*                                 WITH THE NAMELIST  DOINDX             *
CC*           IMAGNO  - AN ARRAY OF IMAGE NUMBERS, IN ASCENDING ORDER,    *
CC*                     OF THOSE IMAGES TO BE PLOTTED FOR A GIVEN TAPE.   *
CC*                     SEE COMMENTS BELOW IN THE SOURCE FOR MORE INFO    *
CC*                                                                       *
CC*         NAMELIST  /IFLAGS/ - PRINT AND PLOT FLAGS                     *
CC*           IPRINT  - ASSUMES A VALUE OF 0, 1 OR 2                      *
CC*             IF  0 - NO OUTPUT TO PRINTER OF MAGNITUDE OR PHASE VALUES*
CC*             IF  1 - MAGNITUDE VALUES ARE OUTPUTTED TO PRINTER         *
CC*             IF  2 - MAGNITUDE AND PHASE VALUES ARE OUTPUTTED          *
CC*           IPLOT   - ASSUMES A VALUE OF 0 OR 1                         *
CC*             IF  0 - NO CONTOUR PLOTTING OF MAGNITUDE VALUES IS DONE   *
CC*             IF  1 - CONTOUR PLOT THE MAGNITUDE VALUES                 *
CC*           ISCALE  - ASSUMES A VALUE OF 0 OR 1                         *
CC*             IF  0 - USER SUPPLIED INPUTS FOR SIZE OF X AND Y AXIS     *
CC*                     (SIZEX,SIZEY) AND NUMBER OF UNITS OF X AND Y PER  *
CC*                     INCH FOR EACH AXIS(XUNITS,YUNITS) ARE PASSED TO   *
CC*                     THE PLOT SUBROUTINE UNCHANGED.                    *
CC*             IF  1 - USER SUPPLIED INPUTS FOR SIZEX,XUNITS,YUNITS      *
CC*                     ARE IGNORED AND THE PROGRAM CALCULATES VALUES     *
CC*                     FOR THE 3 VARIABLES BASED ON THE RATIO OF CROSS   *
CC*                     RANGE CELLS TO DOWN RANGE CELLS. SEE SOURCE       *
CC*                     COMMENTS FOR MORE INFORMATION                     *
CC*                                                                       *
CC*         NAMELIST  /IMPLOT/ - PARAMETERS TO CONTROL THE CONTOUR PLOT   *
CC*                              PROCEDURE.                               *
CC*           NLEV    - NUMBER OF CONTOUR LEVELS DESIRED                  *
CC*           CTHV    - CONTOUR THRESHOLD VALUE(SMALLEST VALUE CONTOURED)*
CC*           CINCR   - INCREMENT BETWEEN CONTOUR LINES                   *
CC*           SIZEX   - SIZE OF X AXIS IN INCHES                          *
CC*           SIZEY   - SIZE OF Y AXIS IN INCHES                          *
CC*           XUNITS  - NUMBER OF UNITS OF X PER INCH(E.G. 1.5M/IN)       *
CC*           YUNITS  - NUMBER OF UNITS OF Y PER INCH                     *
CC*           XMIN    - INITIAL VALUE FOR X AXIS                          *
CC*           YMIN    - INITIAL VALUE FOR Y AXIS                          *
CC*           YORIGN  - POSITION OF X ORIGIN IN INCHES                    *
CC*           XORIGN  - POSITION OF Y ORIGIN IN INCHES                    *
CC*           LABELX  - ARRAY OF CHARACTERS FOR X LABEL                   *
CC*           LABELY  - ARRAY OF CHARACTERS FOR Y LABEL                   *
CC*           LBLSIZ  - NUMBER OF CHARACTERS IN X OR Y LABEL(SAME SIZE)   *
CC*                                                                       *
CC*     TAPE:                                                             *
CC*        RAW WIDEBAND PULSE DATA TO BE CONVERTED TO                     *
CC*        MAGNITUDE VALUES FOR PLOTTING                                  *
```

TABLE B2

PROLOGUES TO ROUTINES ON FILE 2 (CONT.)

```
CC*                                                                   *
CC*   OUTPUTS                                                         *
CC*     SYSPRINT - HEADER RECORD FOR EACH IMAGE. ALSO PHASE           *
CC*                AND MAGNITUDE VALUES IF PRINT FLAG IS "ON"         *
CC*                                                                   *
CC*     PLOTTER - MAGNITUDE VALUES ASSOCIATED WITH EACH IMAGE         *
CC*               ARE CONTOUR PLOTTED ALONG WITH APPROPRIATE          *
CC*               HEADER INFO USING THE VERSATEC PLOTTER              *
CC*                                                                   *
CC*   SUBROUTINES AND FUNCTION SUBPROGRAMS REQUIRED                   *
CC*                                                                   *
CC*     INTERNAL(IBM SUPPLIED) FORTRAN FUNCTIONS                      *
CC*               AIMAG   - EXTRACTS IMAGINARY PORTION OF COMPLEX VAR *
CC*               REAL    - EXTRACTS REAL PORTION OF COMPLEX VARIABLE *
CC*               ATAN2   - TANGENT FUNCTION .RETURNS A 4 QUADRANT RESULT*
CC*               CABS    - ABSOLUTE VALUE OF COMPLEX VARIABLE        *
CC*               INT     - INTERGER PORTION OF FLOATING POINT VARIABLE *
CC*               ALOG10 - LOG FUNCTION                               *
CC*                                                                   *
CC*      EXTERNAL SUBROUTINE:                                         *
CC*               MCCNTR                                              *
CC*                    PURPOSE: PRODUCE CONTOUR PLOT OF DATA          *
CC*                             IN A 2-DIMENSIONAL ARRAY              *
CC*                    REQUIRES: PLOT.AXIS.SYMBOL.NUMBER              *
CC*                    ARGUMENTS (2-DIMENSIONAL ARRAY.PLOT            *
CC*                               PARAMETERS)-SEE DESCRIPTION OF SUB  *
CC*                               MCCNTR FOR MORE DETAILS             *
CC*                                                                   *
CC*   AUTHOR/PROGRAMMER                                               *
CC*      CALSPAN                                                      *
CC*      FEB 1979                                                     *
CC*      P.M.MCMAHON                                                  *
CC*********************************************************************
CC****************************** MCCNTR *******************************
CC**                                                                 **
CC**                         SUBROUTINE MCCNTR                       **
CC**                                                                 **
CC** PURPOSE                                                         **
CC**     TO GENERATE PLOTTED CONTOUR IMAGES OF A 2-DIMENSIONAL ARRAY **
CC**     OF DATA POINTS                                              **
CC**                                                                 **
CC** CALLING SEQUENCE                                                **
CC**     CALL MCCNTR(A.N1.NX.NY.C.NC.XMIN.DX.ALX.YMIN.DY.ALY.X1.Y1.  **
CC**                 XLAB.YLAB.NL.IPXY)                              **
CC**                                                                 **
CC** DESCRIPTION OF PARAMETERS                                       **
CC**    INPUTS:                                                      **
CC**      A    - 2 DIMENSIONAL ARRAY OF POINTS TO BE PLOTTED         **
CC**      N1   - NUMBER OF ROWS IN THE ARRAY IN THE CALLING PROGRAM  **
CC**      NX   - NUMBER OF X VALUES                                  **
CC**      NY   - NUMBER OF Y VALUES                                  **
CC**      C    - 1 DIMENSIONAL ARAY OF CONTOUR LEVELS TO BE PLOTTED  **
CC**      NC   - NUMBER OF CONTOUR LEVELS TO BE PLOTTED              **
CC**      XMIN - X VALUE OF FIRST POINT IN THE ARRAY ( USED AS       **
CC**             THE INITIAL VALUE OF THE X-AXIS)                    **
CC**      DX   - NUMBER OF UNITS OF X/INCH IN THE PLOT (USED AS THE  **
CC**             INTERVAL FOR THE X AXIS)                            **
CC**      ALX  - LENGTH OF X AXIS IN INCHES                          **
CC**      YMIN - Y VALUE OF FIRST POINT IN ARRAY A (USED AS THE      **
CC**             INITIAL VALUE OF THE Y-AXIS)                        **
CC**      DY   - NUMBER OF UNITS OF X/INCH IN THE PLOT (USED AS THE  **
CC**             INTERVAL FOR THE Y-AXIS)                            **
CC**      ALY  - LENGTH OF Y-AXIS IN INCHES                          **
CC**      X1   - COORDINATE IN INCHES OF THE X ORIGIN (ORIGIN RESET  **
CC**             FROM 0.0 TO X1.Y1)                                  **
CC**      Y1   - COORDINATE IN INCHES OF THE Y ORIGIN                **
CC**      XLAB - ARRAY OF CHARACTERS TO BE USED AS THE X LABEL       **
CC**      YLAB - ARRAY OF CHARACTERS TO BE USED AS THE Y LABEL       **
CC**      NL   - NUMBER OF CHARACTERS IN EITHER LABEL (NOTE: LENGTH  **
CC**             OF XLAB = LENGTH OF YLAB)                           **
CC**      IPXY - PLOT FLAG. ALWAYS SET AT 2 FOR THIS TYPE OF DATA .  **
CC**             IPXY = 1- PLOT IS SYMETRIC ABOUT X-AXIS.CORRESPONDING**
CC**                       POINTS PLOTTED IN UPPER QUADRANTS         **
CC**             IPXY = 2- PLOT ONLY THOSE LEVELS FROM THE GIVEN     **
CC**                       POINTS--PLOT THE DATA AS GIVEN            **
CC**                                                                 **
CC** REMARKS                                                         **
CC**     THE REQUESTED CONTOUR LEVELS ARE INTERPOLATED FROM THE DATA **
CC**     POINTS AND THEN WRITTEN TO A DATA SET AND SORTED BEFORE     **
CC**     BEING PLOTTED ON THE VERSATEC                               **
CC**                                                                 **
CC** AUTHOR/PROGRAMMER                                               **
CC**     E.BECKER                                                    **
CC**     FEB 1979                                                    **
CC**     P.M.MCMAHON                                                 **
CC*******************************************************************
```

TABLE B3

PROLOGUES TO ROUTINES ON FILE 3

```
CC****************************** NBAND **********************************
CC*                                                                      *
CC*                    AXD NARROW BAND PLOT PROGRAM                      *
CC*                                                                      *
CC*  PURPOSE                                                             *
CC*     TO READ SELECTED RECORDS OF A TAPE OF NARROW BAND RADAR DATA     *
CC*     WHERE EACH RECORD IS COMPOSED OF RADAR CROSS SECTION,TIME,       *
CC*     ASPECT ANGLE AND PORJECTED ASPECT ANGLE AND THEN PERFORM THE     *
CC*     FOLLOWING OPERATIONS                                             *
CC*     1) SMOOTH THE DATA ACCORDING TO USER SUPPLIED PARAMETERS         *
CC*     2) CALCULATE DESCRIPTIVE STATISTICS ON THE RCS DATA              *
CC*     3) PLOT RCS VS TIME OR RCS VS ASPECT ANGLE OR RCS VS             *
CC*        PROJECTED ASPECT ANGLE                                        *
CC*                                                                      *
CC*  DESCRIPTION OF PARAMETERS                                           *
CC* INPUTS                                                               *
CC*   CARDS:                                                             *
CC*    VARIABLES TO CONTROL SMOOTHING,PLOTTING,STATISTICS,TAPE READING*
CC*     METHOD-                                                          *
CC*       4 NAMELIST READ STATEMENTS ARE USED TO INPUT PARAMETERS        *
CC*         AS SHOWN BELOW:                                              *
CC*                                                                      *
CC*       NAMELIST /READTP/- PARAMETERS TO CONTROL READING OF THE        *
CC*                          INPUT TAPE                                  *
CC*         NREC1 -. THE RECORD NUMBER OF THE INITIAL RECORD TO BE READ *
CC*                  FROM THE TAPE                                       *
CC*         NREC2 - THE RECORD NUMBER OF THE LAST RECORD TO BE READ      *
CC*                 FROM THE TAPE                                        *
CC*                                                                      *
CC*       NAMELIST /IFLAGS/ - CONVERSION,STATISTICS,PLOT AND TYPE        *
CC*                           OF RCS UNITS FLAGS                         *
CC*         ICNVRT - ASSUMES A VALUE OF 0 OR 1                           *
CC*            IF 0 - NO CONVERSION OF RCS DATA BETWEEN SM AND DBSM      *
CC*            IF 1 - CALL SUBROUTINE TO CONVERT RCS ARRAY FROM          *
CC*                   RCS/SM TO RCS/DBSM                                 *
CC*         ISTATS - ASSUMES A VALUE OF 0 OR 1                           *
CC*            IF 0 - DO NOT CALCULATE DESCRIPTIVE STATISTICS ON THE     *
CC*                   RCS DATA ARRAY                                     *
CC*            IF 1 - CALL SUBROUTINE TO CALCULATE DESCRCRIPTIVE STATS   *
CC*         IPLOT - ASSUMES A VALUE OF 0,1,2 OR 3                        *
CC*            IF 0 - NO PLOTTING OF ANY DATA IS PERFORMED               *
CC*            IF 1 - PRODUCE A PLOT OF TIME(X) VS RCS(Y) VALUES         *
CC*            IF 2 - PRODUCE A PLOT OF ASPECT ANGLE(X) VS RCS VALUES    *
CC*            IF 3 - PRODUCE A PLOT OF PROJECTED ASPECT ANGLE(X) VS     *
CC*                   RCS(Y) VALUES                                      *
CC*         TYPRCS - ASSUMES A VALUE OF 0 OR 1                           *
CC*            IF 0 - RCS IN SM UNITS, THEREFORE NO AUTOMATIC SYMETRICAL*
CC*                   SCALING OF RCS(Y) AXIS ABOUT 0                     *
CC*            IF 1 - RCS IN DBSM UNITS, THEREFORE AUTOMATICALLY SCALE   *
CC*                   SYMETRICALLY ABOUT 0 RCS                           *
CC*                                                                      *
CC*       NAMELIST /IPULSE/ - PARAMETERS TO CONTROL SMOOTHING AND        *
CC*                           DATA OUTPUT                                *
CC*         NPLSES - THE NUMBER OF PULSES TO BE AVERAGED TO PRODUCE      *
CC*                  ONE RCS DATA POINT FOR PLOTTING OR STATISTICS       *
CC*         NTHOUT - CONTROLS HOW MANY SMOOTHED DATA POINTS ARE          *
CC*                  OUTPUTED TO PRINTER FOR CHECKING PURPOSED           *
CC*                                                                      *
CC*       NAMELIST /STATS/ - PARAMETERS TO CONTROL THE FREQUENCY         *
CC*                          DISTRIBUTION THAT IS OUTPUTED BY            *
CC*                          THE STATISTICS ROUTINE                      *
CC*                                                                      *
CC*  TAPE:                                                               *
CC*     NARROW BAND RADAR RECORDS COMPOSED OF RADAR CROSS SECTION,       *
CC*     TIME OF OBSERVATION AND TWO ASPECT ANGLES                        *
CC* OUTPUTS:                                                             *
CC*   SYSPRINT - HEADER RECORD FOR THE FILE, A RECORD OF DATA FROM       *
CC*              THE TAPE AT A USER SPECIFIED INTERVAL, AND              *
CC*              DESCRIPTIVE STATISTICS INC. FREQUENCY DISTRIBUTION IF*
CC*              THE ISTATS FLAG IS "ON"                                 *
CC*   PLOTTER - A LINE PLOT OF RCS(DBSM OR SM) VS TIME,ASPECT ANGLE OR*
CC*             PROJECTED ASPECT ANGLE IF IPLOT = 1,2 OR 3 RESPECTIVELY
CC*             USING CALSPANS CALCOMP PLOTTER                           *
CC*
```

TABLE B3

PROLOGUES TO ROUTINES ON FILE 3 (CONT.)

```
CC*     SUBROUTINE AND FUNCTION SUBPROGRAMS REQUIRED                        *
CC*       SMOOTH - PERFORMS SMOOTHING OPERATION ON THE RCS DATA             *
CC*       CONVRT - CONVERTS AN ARRAY OF RCS/SM DATA TO RCS/DBSM DATA        *
CC*       PROIST - CALCULATE MEAN,STANDARD DEVIATION,MIN,MAX AND            *
CC*                FREQUENCY DISTRIBUTION OF AN ARRAY OF RCS DATA           *
CC*       OUT1 - OUTPUTS RESULTS CALCULATED IN PROIST                       *
CC*       PLTTME - DRAWS A PLOT OF RCS VS TIME ON THE CALCOMP               *
CC*       PLTASP - DRAWS PLOT OF RCS VS ASPECT ANGLE OR RCS VS PROJECTED    *
CC*                ASPECT ANGLE ON CALCOMP                                  *
CC*                                                                         *
CC*     AUTHOR/PROGRAMMER                                                   *
CC*         P.M.MCMAHON                                                     *
CC*         APR 1979                                                        *
CC*         CALSPAN CORPORATION                                             *
CC***************************************************************************
CC*
CC*****************************   SMOOTH   *********************************
CC*                                                                         *
CC*                            SUBROUTINE SMOOTH                            *
CC*                                                                         *
CC*    PURPOSE                                                              *
CC*   TO READ NPLSES RECORDS OF DATA FROM THE NARROW BAND TAPE.CALCULATE*
CC*   THE MEAN OF THE RCS DATA POINTS AND SELECT THE MEDIAN TIME,ASPECT *
CC*   ANGLE AND PROJECTED ASPECT VALUES                                     *
CC*                                                                         *
CC*    CALLING SEQUENCE                                                     *
CC*   CALL SMOOTH(NPLSES,RCSVAL,TMEVAL,ASPCT1,ASPCT2,EOF)                   *
CC*                                                                         *
CC*    DESCRIPTION OF PARAMETERS                                            *
CC*   INPUTS                                                                *
CC*    ARGUMENT LIST:                                                       *
CC*     NPLSES - USER DEFINED VALUE FOR THE NUMBER OF RECORDS TO BE         *
CC*     READ AND AVERAGED                                                   *
CC*    TAPE:                                                                *
CC*     NARROW BAND RADAR TAPE WITH RECORDS COMPOSED OF A RCS VALUE,        *
CC*     TIME VALUE AND 2 ASPECT ANGLES                                      *
CC*   OUTPUTS                                                               *
CC*    ARGUMENT LIST:                                                       *
CC*     RCSVAL - MEAN OF THE RCS VALUES(AFTER CONVERTING UNITS FROM DBSM*
CC*              TO SM) FOR NPLSES RECORDS                                  *
CC*     TMEVAL - MEDIAN TIME VALUE OF THE NPLSES RECORDS                    *
CC*     ASPCT1 - MEDIAN ASPECT ANGLE OF THE NPLSES RECORDS                  *
CC*     ASPCT2 - MEDIAN PROJECTED ASPECT ANGLE OF THE NPLSES RECORDS        *
CC*     EOF    - END OF FILE FLAG. SET TO 1 IF EOF IS REACHED WHILE         *
CC*              READING THE TAPE WITHIN SMOOTH                             *
CC*                                                                         *
CC*    REMARKS                                                              *
CC*     THE MAIN PROGRAM ADVANCES THE TAPE TO THE STARTING RECORD AND       *
CC*     TESTS FOR THE END-OF-FILE CONDITION. IF EOF=1, THE OTHER VALUES *
CC*     BEING RETURNED ARE IGNORED                                          *
CC*                                                                         *
CC*    SUBROUTINE AND FUNCTION SUBPROGRAMS REQUIRED                         *
CC*   NONE                                                                  *
CC*                                                                         *
CC*    AUTHOR/PROGRAMMER                                                    *
CC*        P.M.MCMAHON                                                      *
CC*        APR 1979                                                         *
CC*        CALSPAN CORPORATION                                              *
CC***************************************************************************
CC*****************************   CONVRT   *********************************
CC*                                                                         *
CC*                            SUBROUTINE CONVRT                            *
CC*                                                                         *
CC*    PURPOSE                                                              *
CC*   CONVERTS AN ARRAY OF RCS(SM) DATA TO RCS(DBSM)                        *
CC*                                                                         *
CC*    CALLING SEQUENCE                                                     *
CC*   CALL CONVRT(N,RCSQDB)                                                 *
CC*                                                                         *
CC*    DESCRIPTION OF PARAMETERS                                            *
CC*   INPUTS                                                                *
CC*     N - NUMBER OF DATA POINTS IN THE RCS ARRAY(MAX=10000)               *
CC*     RCSQDB - THE RCS ARRAY IN ORIGINAL(SQ. M) UNITS                     *
CC*   OUTPUTS                                                               *
CC*     RCSQDB - THE RCS ARRAY IN CONVERTED(DBSM) UNITS FOR PLOTTING        *
CC*                                                                         *
CC*    REMARKS                                                              *
CC*     THE ORIGINAL UNITS ON THE TAPE IS DBSM HOWEVER, THE SMOOTH SUB      *
CC*     CONVERTS TO SM BEFORE AVERAGING.  THIS ROUTINE CONVERTS BACK TO *
CC*     DBSM FOR PLOTTING OR STATISTICS                                     *
```

TABLE B3

PROLOGUES TO ROUTINES ON FILE 3 (CONT.)

```
CC*     SUBROUTINE AND FUNCTION SUBPROGRAMS REQUIRED                     *
CC*      IBM SUPPLIED LOG FUNCTION  ALOG10                                *
CC*                                                                       *
CC*     AUTHOR/PROGRAMMER                                                 *
CC*         P.M.MCMAHON                                                   *
CC*         APR 1979                                                      *
CC*         CALSPAN CORPORATION                                           *
CC************************************************************************
C************************************************************************
C*      SUBROUTINE PRDIST                                                *
C*                                                                       *
C*      PURPOSE                                                          *
C*                                                                       *
C*          EVALUATION OF DATA STATISTICS                                *
C*            1) MEAN VALUE                                              *
C*            2) STANDARD DEVIATION                                      *
C*            3) MAXIMUM                                                 *
C*            4) MINIMUM                                                 *
C*            5) HISTOGRAM(FREQUENCIES OF OCCURRENCE)                    *
C*            6) CUMULATIVE DISTRIBUTION                                 *
C*                                                                       *
C*      USAGE                                                            *
C*                                                                       *
C*      CALL PRDIST(X,NP,A,B,C,D,E)                                      *
C*                                                                       *
C*      WHERE                                                            *
C*                                                                       *
C*          X IS THE NAME FOR THE DATA ARRAY                             *
C*      NP IS THE NUMBER OF DATA POINTS                                  *
C*          A,B,C,.... DEFINE CELL SIZES AS                              *
C*              A(B)C(D)E - ( THAT IS, A TO C IN INCREMENTS OF SIZE B,   *
C*                          THEN TO E IN INCREMENTS OF SIZE D).          *
C*              FOR A(B)C, SET E=D=C OR SET E= 0.0.                      *
C*                                                                       *
C*      REMARKS                                                          *
C*                                                                       *
C*          RESULTS ARE LEFT IN LABELED COMMON LCPROB, DEFINED BY        *
C*          COMMON/LCPROB/ NBUCK(101),DIST(101),CELLI(102),XMAX,XMIN,    *
C*                         XBAR,DEV,KI,NX                                *
C*                                                                       *
C*          NBUCK(I) IS THE NO. OF OCCURRENCES(INTEGER) FOR THE ITH CELL. *
C*          DIST(I) IS THE CUMULATIVE DISTRIBUTION(FLOATING POINT VALUE IN*
C*                  INTERVAL 0.0 TO 1.0) CORRESPONDING TO THE RIGHT HAND *
C*                  EDGE OF THE ITH CELL.                                *
C*          CELLI(I),CELLI(I+1) DEFINE THE LEFT AND RIGHT HAND EDGES,    *
C*                  RESPECTIVELY, OF THE ITH CELL. (CELLI(1) IS SET TO   *
C*            -10**75 CELLI(KI+1)  IS SET TO 10**75 BY THE PROGRAM       *
C*          XMAX,XMIN ARE MAXIMUM AND MINIMUM X VALUES, RESPECTIVELY.    *
C*          XBAR IS THE COMPUTED AVERAGE VALUE FOR THE X S.              *
C*          DEV IS THE COMPUTED STANDARD DEVIATION FOR THE X S.          *
C*          KI IS THE NUMBER OF INTERVALS.                               *
C*      NX IS THE NUMBER OF DATA POINTS (= NP)                           *
C*                                                                       *
C*      SUBROUTINE AVAILABLE                                             *
C*                                                                       *
C*          THIS ROUTINE IS AN OPTIONAL OUTPUT ROUTINE COMPATIBLE WITH   *
C*          THE PRECEDING PRDIST ROUTINE.                                *
C*          CALLING SEQUENCE - CALL OUT1                                 *
C*          A SKIP TO A NEW SHEET PLUS A HEADER LINE SHOULD BE SUPPLIED BY*
C*          THE USER IN THE MAIN PROGRAM.                                *
C*                                                                       *
C************************************************************************
C************************************************************************
C*      SUBROUTINE OUT1                                                  *
C*      PURPOSE                                                          *
C*         PRINT OUTPUT OF DATA STATISTICS FROM SUBROUTINE PRDIST        *
C*      USAGE                                                            *
C*         CALL OUT1                                                     *
C*      REMARKS                                                          *
C*         SAMPLE PRINT OUT COULD LOOK LIKE THIS.                        *
C*         MEAN= 11.42 SIGMA= 8.6236 MAX.= 30.00 MIN= 1.00  NO. PTS.=200 *
C*               CELL        FREQ.   CUM.            CELL        FREQ.   CUM. *
C*          ***** -     0.        0    0.       10.00 -  12.00     20   60.00 *
C*           0.   -     1.00      0    0.       12.00 -  14.00     10   65.00 *
C*           1.00 -     2.00     20   10.00     14.00 -  16.00     10   70.00 *
C*           2.00 -     3.00     10   15.00     16.00 -  18.00     20   80.00 *
C*           3.00 -     4.00     10   20.00     18.00 -  20.00     10   85.00 *
C*           4.00 -     5.00     10   25.00     20.00 -  22.00      5   87.50 *
C*           5.00 -     6.00     10   30.00     22.00 -  24.00      0   87.50 *
C*           6.00 -     7.00     10   35.00     24.00 -  26.00      5.  90.00 *
C*           7.00 -     8.00     10   40.00     26.00 -  28.00      0   90.00 *
C*           8.00 -     9.00     10   45.00     28.00 -  30.00      0   90.00 *
C*           9.00 -    10.00     10   50.00     30.00 - *****      20  100.00 *
C*                                                                       *
C*         A SKIP TO A NEW SHEET PLUS A HEADER LINE SHOULD BE SUPPLIED   *
C*         BY THE USER IN THE MAIN CALLING PROGRAM.                      *
C************************************************************************
```

TABLE B3

PROLOGUES TO ROUTINES ON FILE 3 (CONT.)

```
CC****************************** PLTTME ******************************
CC*                                                                  *
CC*                    SUBROUTINE PLTTME                             *
CC*                                                                  *
CC*   PURPOSE                                                        *
CC*    DRAW A LINE PLOT OF RADAR CROSS SECTION(DBSM OR SM) VS TIME FOR *
CC*    REAL OR DERIVED(FROM WIDEBAND) NARROW BAND RADAR DATA.        *
CC*                                                                  *
CC*   CALLING SEQUENCE                                               *
CC*  CALL PLTTME(TIME,RCSDTA,NDPTS,NREC1,NREC2,NPULSE,NOBJ,FLG)      *
CC*                                                                  *
CC*   DESCRIPTION OF PARAMETERS                                      *
CC*  INPUTS                                                          *
CC*   ARGUMENT LIST:                                                 *
CC*       TIME - ARRAY OF TIME DATA POINTS TO BE PLOTTED             *
CC*       RCSDTA - ARRAY OF RCS DATA POINTS TO BE PLOTTED            *
CC*       NDPTS - ARRAY OF RCS DATA POINTS IN TIME OR RCSDTA         *
CC*       NREC1 - POSITION OF FIRST RECORD READ FROM TAPE - TO PROVIDE *
CC*               IDENTIFICATION INFORMATION ON THE PLOTTED OUTPUT   *
CC*       NREC2 - POSITION OF LAST RECORD READ FROM TAPE - TO PROVIDE *
CC*               IDENTIFICATION INFORMATION AS ABOVE                *
CC*       NPULSES - SMOOTHING INTERVAL SELECTED BY USER - FOR PLOT   *
CC*                 IDENTIFICATION                                   *
CC*       NOBJ - OBJECT NUMBER - FOR PLOT IDENTIFICATION             *
CC*       FLG - A FLAG THAT CONTROLS AUTOMATIC SYMETRICAL SCALING OF *
CC*             RCS DATA (Y AXIS) ABOUT 0I.E. IF FLG=1. SCALING IS   *
CC*             AUTOMATIC. IF NOT 1. USER MUST SUPPLY BEGINNING AND  *
CC*             ENDING POINTS OF THE Y AXIS                          *
CC*  OUTPUTS:                                                        *
CC*       LINE PLOT OF RADAR CROSS SECTION VERSUS TIME WITH APPROPRIATE *
CC*       IDENTIFICATION INFORMATION ON CALSPANS CALCOMP PLOTTER     *
CC*                                                                  *
CC*   SUBROUTINE AND FUNCTION SUBPROGRAMS REQUIRED                   *
CC*  CALSPAN PLOT SUBROUTINES                                        *
CC*       PLOT - BASIC PLOT SUB USED BY HIGHER LEVEL PLOT ROUTINES   *
CC*       AXIS - DRAWS X OR Y AXIS WITH TIC MARKS AND LABELS         *
CC*       SYMBOL - DRAWS ALPHA CHARACTERS OF SPECIFIC SIZE AND LOCATION *
CC*       NUMBER - DRAWS NUMERIC INFORMATION OF SPECIFIED SIZE AT    *
CC*       A SPECIFIED LOCATION                                       *
CC*       LINE - DRAWS A STRAIGHT LINE BETWEEN POINTS DEFINED BY     *
CC*              SUCCESSIVE ELEMENTS OF X AND Y ARRAYS               *
CC*  IBM SUPPLIED FORTRAN FUNCTIONS                                  *
CC*       INT - RETURNS INTEGER PORTION OF FLOATING PLOINT NUMBER    *
CC*       AMAXI - RETURNS MAXIMUM VALUE OF ARG OF FLOATING PT NUMBERS *
CC*       AMINT - RETURNS MINIMUM VALUE OF ARG OF FLOATING PT NUMBERS *
CC*                                                                  *
CC*   AUTHOR/PROGRAMMER                                              *
CC*       P.M.MCMAHON                                                *
CC*       APR 1979                                                   *
CC*                                                                  *
CC*******************************************************************
```

TABLE B3

PROLOGUES TO ROUTINES ON FILE 3 (CONT.)

```
CC*****************************  PLTASP  ******************************
CC*                                                                   *
CC*                      SUBROUTINE PLTASP                            *
CC*                                                                   *
CC*   PURPOSE                                                         *
CC*    DRAW A LINE PLOT OF RADAR CROSS SECTION(DBSM OR SM) VS ASPECT  *
CC*    ANGLE OR PROJECTED ASPECT ANGLE FOR SELECTED PORTIONS OF NARROW *
CC*    BAND RADAR TAPE                                                *
CC*                                                                   *
CC*   CALLING SEQUENCE                                                *
CC*  CALL PLTASP(ANGLE,RCSDTA,NDPTS,NREC1,NREC2,NPULSE,NOBJ,FLG)      *
CC*                                                                   *
CC*   REMARKS                                                         *
CC*    IN ORDER FOR THIS PLOT SUBROUTINE TO WORK PROPERLY THE DATA THAT*
CC*    IS PASSED TO IT MUST BE IN ASCENDING OR DESCENDING ORDER--     *
CC*    THEREFORE UTMOST CARE MUST BE USED IN SPECIFYING  NREC1 AND NREC2
CC*    TO INSURE THAT THE ANGLE CHOSEN IS  INCREASING OR DECREASING   *
CC*    IN ONE DIRECTION ONLY                                          *
CC*                                                                   *
CC*   DESCRIPTION OF PARAMETERS                                       *
CC*  INPUTS                                                           *
CC*   ARGUMENT LIST:                                                  *
CC*       ANGLE - ARRAY  OF ASPECT ANGLE OR PROJECTED ASPECT ANGLE DATA *
CC*               POINTS TO BE PLOTTED                                *
CC*       RCSDTA - ARRAY OF RCS DATA POINTS TO BE PLOTTED             *
CC*       NDPTS - ARRAY OF RCS DATA POINTS IN TIME OR RCSDTA          *
CC*       NREC1 - POSITION OF FIRST RECORD READ FROM TAPE - TO PROVIDE *
CC*               IDENTIFICATION INFORMATION ON THE PLOTTED OUTPUT    *
CC*       NREC2 - POSITION OF LAST RECORD READ FROM TAPE - TO PROVIDE *
CC*               IDENTIFICATION INFORMATION AS ABOVE                 *
CC*       NPULSES - SMOOTHING INTERVAL SELECTED BY USER - FOR PLOT    *
CC*                 IDENTIFICATION                                    *
CC*       NOBJ - OBJECT NUMBER - FOR PLOT IDENTIFICATION              *
CC*       FLG - A FLAG THAT CONTROLS AUTOMATIC SYMETRICAL SCALING OF  *
CC*             RCS DATA (Y AXIS) ABOUT 0I.E. IF FLG=1, SCALING IS    *
CC*             AUTOMATIC. IF NOT 1, USER MUST SUPPLY BEGINNING AND   *
CC*             ENDING POINTS OF THE Y AXIS                           *
CC*  OUTPUTS:                                                         *
CC*       LINE PLOT OF RADAR CROSS SECTIPN VS ASPECT ANGLE OR PROJECTED *
CC*       ASPECT ANGLE WITH APPROPRIATE IDENTIFYING INFORMATION ON    *
CC*       CALSPANS CALCOMP PLOTTER                                    *
CC*                                                                   *
CC*   SUBROUTINE AND FUNCTION SUBPROGRAMS REQUIRED                    *
CC*  CALSPAN PLOT SUBROUTINES                                         *
CC*       PLOT - BASIC PLOT SUB USED BY HIGHER LEVEL PLOT ROUTINES    *
CC*       AXIS - DRAWS X OR Y AXIS WITH TIC MARKS AND LABELS          *
CC*       SYMBOL - DRAWS ALPHA CHARACTERS OF SPECIFIC SIZE AND LOCATION *
CC*       NUMBER - DRAWS NUMERIC INFORMATION OF SPECIFIED SIZE AT     *
CC*       A SPECIFIED LOCATION                                        *
CC*       LINE  - DRAWS A STRAIGHT LINE BETWEEN POINTS DEFINED BY     *
CC*               SUCCESSIVE SEGMENTS OF X AND Y ARRAYS               *
CC*  IBM SUPPLIED FORTRAN FUNCTIONS                                   *
CC*       INT - RETURNS INTEGER PORTION OF FLOATING PLOINT NUMBER     *
CC*       AMAX1 - RETURNS MAXIMUM VALUE OF ARG OF FLOATING PT NUMBERS *
CC*       AMIN1 - RETURNS MINIMUM VALUE OF ARG OF FLOATING PT NUMBERS *
CC*                                                                   *
CC*   AUTHOR/PROGRAMMER                                               *
CC*        P.M.MCMAHON                                                *
CC*        APR 1979                                                   *
CC*                                                                   *
CC*********************************************************************
CC*                                                                   *
CC*********************************************************************
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